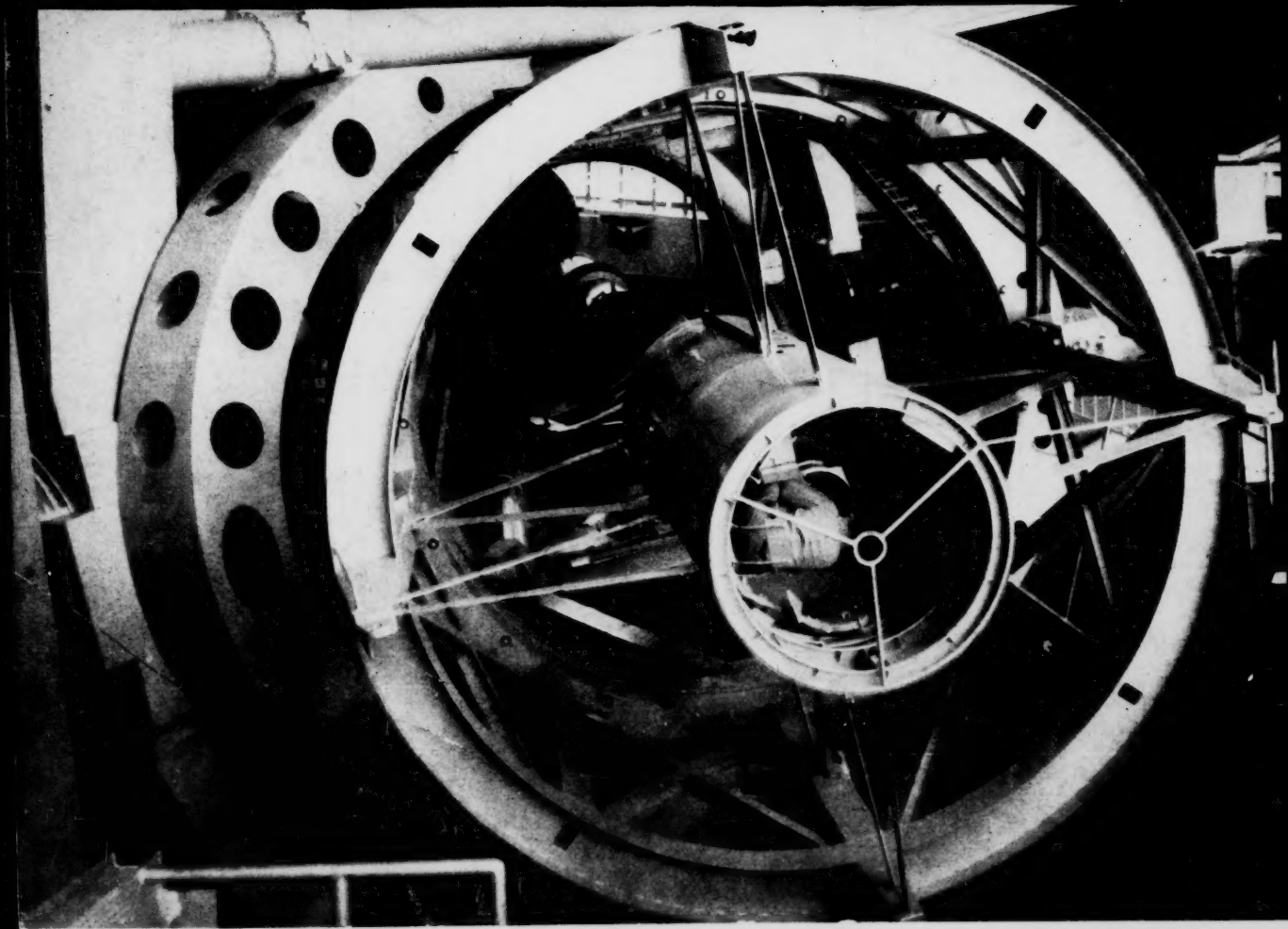

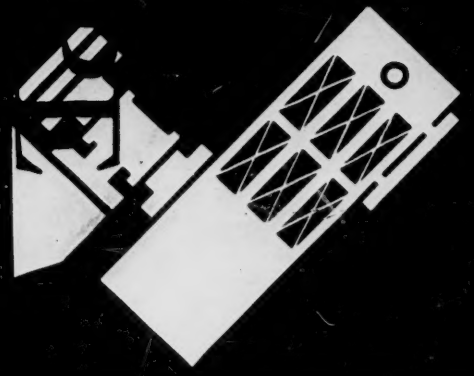

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evenings, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill. Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P.O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Curator, Gordon A. Atwater.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings as 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Tuesday and Sunday, 4 p.m. Special showings on request. Admission free. Spitz projector. Director, Ernest T. Ludhe.

Sky and TELESCOPE

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LETTERS

Sir:

In his letter on page 298 of the October issue, H. H. Nininger states that the recently identified Wolf Creek crater in Western Australia "is the only large crater so far discovered that has been produced by other than the siderite [nickel-iron] type of meteorite. It is said that the specimens found are of the ironstone type. Only the small (55 by 36 feet) Haviland crater in Kansas had previously been credited to this type of meteorite . . . . A reasonable explanation for the broader, shallower form of the Wolf Creek crater would seem to be that the brittle stony constituents of the iron-stone type of meteorite rendered it less coherent under the strain of impact so that it exploded before penetrating so great a depth of sediments."

The "ironstone" mentioned in all the original reports that I have seen concerning the crater does not belong to the **siderolitic** (irony-stone and stony-iron) division of meteorites, but it is what is commonly called "iron-shale," which is terrestrially oxidized meteoritic nickel-iron. This point is made perfectly clear in another article on the crater, by Frank Reeves (one of its discoverers) and R. O. Chalmers, published in the **Australian Journal of Science,** Vol. 11, No. 5, pages 154-156, April, 1949, and reviewed in "Contributions of The Meteoritical Society," **Popular Astronomy,** Vol. 57, pages 405-406, October, 1949. A single quotation from Reeves' and Chalmers' paper will elucidate the matter:

"The specimen [of ironstone] . . . is therefore an oxidation product of an iron meteorite. It is practically identical in appearance with the 'iron-shale' described from the Henbury Meteorite Craters in Central Australia . . . . Such oxidation products of iron meteorites are described also from other localities, including the famous Meteorite Crater of Canyon Diablo in Arizona, U.S.A."

The Wolf Creek crater, like all the other great meteoritic craters of the world so far known, was formed doubtless by the infall of a giant meteorite, or a swarm of meteorites, of the sideritic or nickel-iron type.

FREDERICK C. LEONARD
University of California,
Los Angeles, Calif.

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PROGRESS IN RADIO ASTRONOMY-I

BY OTTO STRUVE, *Yerkes and McDonald Observatories*

In the April issue of *Sky and Telescope*, Grote Reber gave an account of some of his investigations in radio astronomy. During a recent visit to Europe I have discussed this topic with several European astronomers and physicists. There have been many recent advances in this field which grip the imagination and should be of interest to the readers of this magazine. — O.S.

THERE is no essential difference between the ordinary radiations of light and heat and those which are recorded by the radio. A perfect black body raised to a temperature of about 6,000° resembles the sun in its emission of visible light and of heat. But it also radiates waves of much greater length than even the longest which we usually describe as heat rays, although all parts of the spectrum produce a heating effect which is proportional to the amount of radiant energy at the point where the temperature is measured.

It is possible to compute exactly the intensity of the radiation for different wave lengths using a theoretical formula derived by Max Planck. Thus, Fig. 1, taken from a recent publication by C. R. Burrows, shows the distribution of radiant energy coming to us from the sun. Visual and photographic observations cover only the small wave-length interval between about 0.3μ (micron) and 1μ (one micron is 1/1,000 of a millimeter). This radiation is consistent with a temperature of about 5,713° absolute. Planck's formula then predicts in the radio range a distribution indicated by the almost straight line labeled $T_\nu = 5{,}713°$ K. But the sun and the stars are not black bodies in the sense a physicist would use this term. Hence we must expect a departure of the observed amount of radio emission from the Planck formula.

A useful chart of the various electromagnetic radiations has been prepared by R. E. Williamson and is shown in Fig. 2. The radio waves which are considered in this article occur between wave lengths of about one centimeter and about 10 meters. In the figure they are indicated as microwaves. The reader will notice that on the side of short

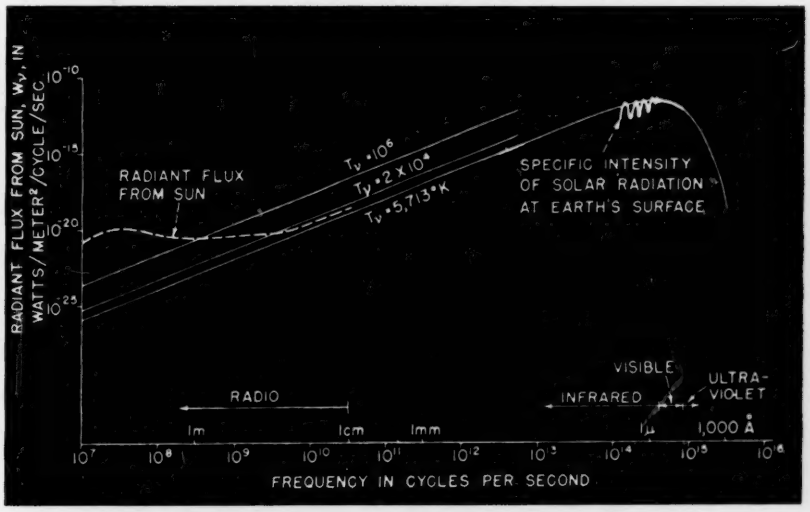


Fig. 1. The distribution of intensity in the spectrum of the sun, as observed and as computed. In the optical range a window of transparency in the atmosphere of the earth permits us to record sunlight between about 1μ and 1/3μ in wave length. For longer wave lengths the atmosphere is almost opaque because of heavy absorption by the molecules of air, but infrared detectors have observed small intervals of the solar spectrum up to about 25μ. Another large transparent region is in the radio range between about one centimeter and one or more meters. In the unobserved opaque intervals the approximate distribution of sunlight can be computed with the help of Planck's formula, assuming a suitable temperature. This figure is adapted from a paper by C. R. Burrows, of Cornell University, in "Electronics," February, 1949.

waves this region is immediately joined by another region extending to wave lengths of the order of about 1/1,000 of a millimeter, which is important in the study of molecular spectra. The ordinary visual and photographic region centers at about 5/10,000 of a millimeter, and this is succeeded by still shorter waves described as the ultraviolet and as X-rays.

One difficulty which an astronomically trained reader has in understanding the language of the radio engineer is that the latter expresses the wave lengths not in centimeters but in terms of cycles per second, for which the scale is shown at the top of the figure. This is simply the frequency. If a radio engineer speaks of 10^{10} cycles per second, the corresponding wave length is roughly three centimeters.[1] Quite often the term mega-cycles per second is used instead. This is an abbreviation, *mega* standing for a million, so that one megacycle is a million cycles per second.

There can be no doubt that K. G. Jansky's discovery of cosmic radio noise in 1931 must be regarded as a very important advance in the history of our science. A few weeks ago Sir Edward Appleton, the famous British explorer of the ionosphere, described this work as one of the most brilliant discoveries in the whole field of physical science. Indeed, if we contemplate that no one had even the slightest suspicion that radio waves could penetrate into the atmosphere of the earth with an intensity sufficient to be recorded with ordinary radio receiving sets, it is clear that Jansky displayed an extraordinary skill and an equally remarkable insight when he announced that the source of the static was somehow connected with the Milky Way.

The next step in this field was made by Grote Reber, and to him, more than to anyone else, belongs the credit for having convinced astronomers that here was a new and fruitful field of exploration. I should like to record a few personal recollections in connection with

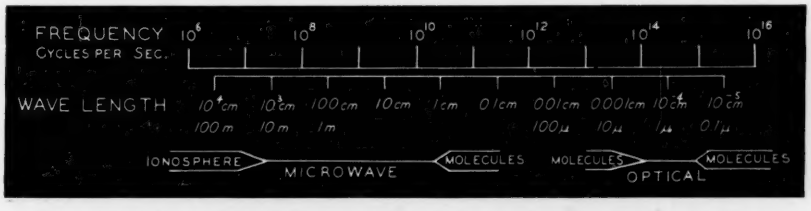
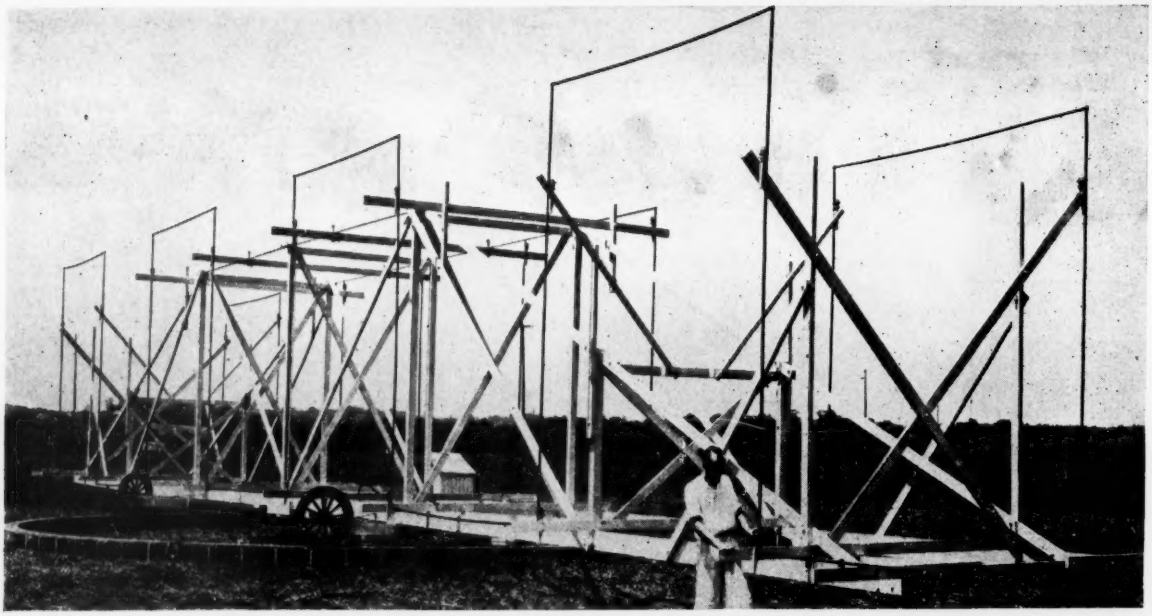


Fig. 2. A scale showing the conversion of the units employed by astronomers and by radio engineers to describe the wave length and frequency of electromagnetic radiation. From the RASC "Journal," Jan.-Feb., 1948.

[1]The relation is: wave length times frequency equals velocity. For electromagnetic radiation the velocity is that of light, nearly 3 x 10^{10} centimeters per second.



The radio antenna system employed in 1932 by K. G. Jansky to detect radio disturbances in the atmosphere, and with which the horizontal component of noise from the Milky Way was discovered. National Bureau of Standards photograph.

Mr. Reber's work. As a radio engineer in Chicago, he was completely unknown to astronomers. I remember his first visit to the Yerkes Observatory after he had taken a course in astrophysics under Professor Bengt Strömgren on the campus in Chicago, in order to have the astronomical data he required for the explanation of his observations. Mr. Reber was already convinced that he had found a remarkable confirmation of Jansky's early work, which because of the technical difficulties of radio engineering had remained comparatively little known to astronomers, so that even Jansky's article on "Electrical Phenomena that Apparently are of Interstellar Origin" in *Popular Astronomy*, Vol. 41, page 548, 1933, aroused only mild interest.

Mr. Reber brought with him a large stack of tracings on which his instrument had recorded the intensity of the radiation from the sky at a wave length of slightly less than two meters. The tracings had the outward appearance of a microphotometer record. There was clearly indicated a general bulge of the red line drawn by the recording instrument at the exact time the Milky Way passed over his antenna. An annoying factor was the presence of numerous violent and sharp disturbances which Mr. Reber explained to us were the result of various electrical appliances, such as a dentist's drill a block or two away, a trolley line on a street in his vicinity, or the faulty ignition of a passing car.

As we continued our discussion with Mr. Reber, and especially after G. P. Kuiper had visited him at his house in Wheaton, Ill., and inspected the remarkable radio telescope which he had built at his own expense and according to his own designs, we began to see emerging before our eyes a completely new branch of astronomy. It was surprising to us, as it was to all other astronomers, that the intensity of the radio radiation was greatest from the Milky Way and followed closely the optical isophotes which had been drawn by Pannekoek and others. But the most astonishing result of all was the relative weakness of the intensity of this radiation from the sun. The publication of Reber's first results in the *Astrophysical Journal* for 1940 was the beginning of a concerted effort on the part of astronomers and radio engineers to explain the source of the radio radiation.

Perhaps it may be useful to start by drawing an imaginary picture of what an observer would see from the earth if his eyes were sensitive to the range of wave lengths indicated as microwaves in Fig. 2. Of course we must not think of a human being equipped with an ordinary pair of eyes, because the wave lengths of the radio radiation are far too long to be examined with the help of an optical instrument. But we can imagine a device resembling the antenna of a radio set and endowed with a relative resolving power comparable to that of the eye. We must next imagine that this device possesses a sensitivity far in excess of what the eye possesses in the range of ordinary visual light. It is perhaps the greatest triumph of radio engineering that its modern devices permit us to record intensities which are very much fainter than those that can be recorded on a photographic plate.

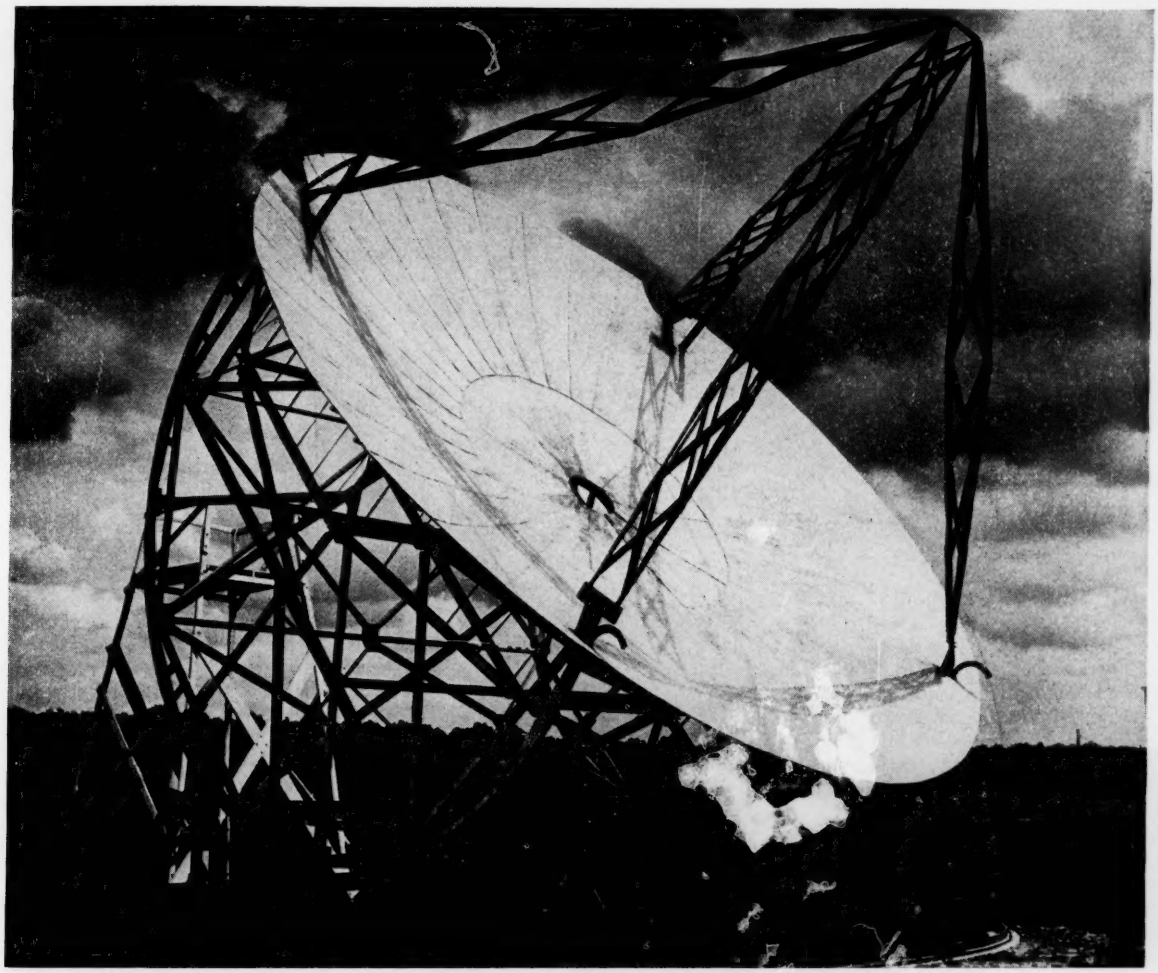
The sky would appear as having a faintly luminous background, on top of which the structure of the Milky Way would appear with considerable distinctness. There would be a brilliant region in the constellation of Sagittarius where the center of the galaxy is located. An observer who could use filters sensitive for different wave lengths, in the radio range, would detect a remarkable tendency of the structure of the Milky Way to become more and more diffuse as the wave length was increased. For example, at a wave length of about five meters, Hey, Phillips, and Parsons found relatively little concentration of intensity in the Milky Way, while at approximately half a meter wave length Reber recorded the isophotes with distinctness comparable to that of the visual observations.

Approximately three years ago, Hey, Phillips, and Parsons discovered a new feature in the radio radiation from the night sky. Reber had already found a bright region in the constellation Cygnus. The British physicists noticed that radiation from the Cygnus region was not constant but oscillated in an irregular fashion, like a twinkling star, with an average interval between successive brightenings of the order of approximately 10 seconds. Our hypothetical observer would notice not only this twinkling object in Cygnus but, according to recent work by M. Ryle and others at Cambridge, he would discover a dozen or two other, approximately starlike objects, some of which are nearly constant in radio light, while others possess the same twinkling characteristics which were first noticed in the Cygnus object.

Our observer would be almost unaware of the passage of day and night, and he would record the same intensity

of radiation whether or not the sun or the moon happened to be above the horizon. Nor would he notice the existence of clouds in our atmosphere, since his radio eye would penetrate through even the densest clouds without noticing any absorption. He would be unable to discover the existence of dust clouds in the galaxy and would observe light from the background sky as well as light from the starlike objects in regions which are completely opaque in optical waves. He would soon find that the surfaces of the earth, especially that of the sea, are almost perfect reflectors, and would even make use of this property to enhance the intensity of the radiation captured by his antenna-like eyes. In some of the longer wave lengths he would discover that the earth is surrounded by an opaque surface, the ionosphere, and he would speak of a "radio window" through which he could see the world outside, as we might speak of the "optical window" through which we observe visual and photographic radiations. A careful study of the distribution of intensity with wave length would reveal to him a relatively slight change. He would not be aware of any such clear-cut relation between color and other characteristics of stars as we know in the optical region.

If our observer should try to examine the radiation of the sun he would be able to notice it as a relatively feeble source on top of the general radiation of the sky. Prolonged observations would convince him that the sun is highly irregular, much more so than in visual light. Most of the time he would observe a relatively constant amount of radio radiation, but, strange to say, he would find that the diameter of the sun as measured in different wave lengths of the radio spectrum depended very markedly upon the wave length to which his eye was tuned. For example, in the region of 10-centimeter waves the sun would look to him as a faintly luminous area having a diameter of approximately 30 minutes of arc and possessing an extremely brilliant narrow edge. Contrary to our experience in visual light, which has made us accustomed to think of a star being dimmer at the limb than at the center, he would conclude that there is a marked brightening toward the limb. At a wave length of 10 meters, the diameter of the sun would appear to him almost twice as large as that recorded at 10 centimeters; there would be no longer any indication of a brilliant outer rim. Instead, the light would diminish gradually toward the outside. A theoretician would undoubtedly conclude that in the longer wave lengths the radiation comes mostly from the outer regions of the corona, the inner regions being effectively opaque to these waves, while at the shorter wave lengths the radiation comes in part from the chromosphere and in part from the corona. If our observer should inquire into the reason for this constant solar radiation, he would notice that at the shorter wave lengths, of the order of 10 centimeters, the observations can be explained by assuming that the chromosphere and the corona consist of a highly ionized gas at a temperature of the order of 6,000-10,000°. This is not far removed from the temperature attributed by conventional methods to the



Grote Reber's original receiver for the study of Milky Way radio noise, now set up at the Bureau of Standards station at Sterling, Va. When this picture was taken, the receiving apparatus was not in place at the focus. "Scientific American" photograph by K. Chester.

outer layers of the solar atmosphere. But at wave lengths of the order of 10 meters, the corresponding temperature would be about one million degrees, and this reminds us of the high temperature which we have for some time attributed to the solar corona.

If our observer should continue his study of the sun over a period of several days, he would quickly notice that on top of this quiescent solar radiation there exists a widely fluctuating radiation which at times imitates a temperature of the order of 10^{13} degrees. This variability of the sun's radiation in the domain of radio waves forms one of the most remarkable differences between results of the radio astronomer and those of the visual or photographic astronomer. The work of C. G. Abbot and others in the visual spectrum has shown that the variations of the sun's light are of the order of only a few per cent. In the radio region the variations are often several hundred or even several thousand per cent. Perhaps it is fortunate that the sun is not variable in this sense when we examine it with optical means; a change by a factor of several thousand might easily affect our daily lives or might even render our planet uninhabitable! But let us not be deceived about the importance of the extreme variations in the radio region. In terms of the total radiant energy of the sun, even the most violent outbursts in the 10-meter waves form only a minute fraction.

On July 25, 1946, there occurred an unusually large eruption on the sun which was accompanied by a large increase in the emission of radio waves. According to A. C. B. Lovell and C. J. Banwell, the total radio radiation of the sun during this flare exceeded that of the quiescent sun by a factor of about 500,000. But it has been established that the solar eruption occupied only a very small part of the sun's surface. A. Unsöld has pointed out that in all probability the radio waves came from a part of the solar corona which was excited by the surface flare, but which itself could not have been much larger than an area having a radius of the order of 5,000 kilometers. If we make allowance for the fact that the excited region was in reality very small, we find that inside of it the radio waves were about a million million times more intense than on the surface of the quiescent sun. Such tremendous variations are entirely new in the field of astrophysics, and they constitute one of the most challenging problems with which we have to deal.

Next in importance is the question of the radio stars. A plot of these small regions on a map of the sky shows that they are not appreciably concentrated toward the Milky Way. We shall consider the observational evidence and possible explanations next month.

(To be concluded)

The Temperature Gradient in the Chromosphere

IN THE LAST DECADE, astronomers have considerably changed their picture of the sun's atmosphere. No longer does the enormous extent of a relatively cool solar atmosphere puzzle us, for we now know that it is really not so cool. The principle of a decrease in temperature with increasing height above the surface of the sun has seemed obvious, but Edlén's identification of the coronal lines as belonging to such atoms as 14-times ionized iron forced the realization that for a long time there has been evidence that the sun's corona is "hotter" than the photosphere. By a "hot" corona, astronomers refer to the measure of the atoms' speed — their kinetic temperature. Since it is the random motion of the atoms which distends the atmosphere, this concept of temperature is important in considering the solar temperature gradient.

In the absence of satisfactory theories to describe the mechanism by which the sun's atmosphere is "heated," Dr. Richard N. Thomas, of the Institute for Advanced Study, Princeton University (and now of the University of Utah), at the Ottawa meeting of the American Astronomical Society in June, reported on what may be a new method of interpreting one kind of old data to find the atmospheric characteristics from observation alone. Earlier, at Harvard, Dr. Thomas had attempted to derive on a theoretical basis some of the properties of an atmosphere where temperatures relating to radiation and atomic motions differed. His studies led him to suspect a greater influence of self-absorption in the eclipse flash spectrum of hydrogen than earlier workers had thought possible. His current work is an attempt to apply these ideas to eclipse observations, using data gathered in 1932 by a Harvard group led by Dr. Donald H. Menzel.

If a thin layer of radiating gas be observed, the radiation in a spectral line will be simply the amount radiated by one atom times the number of atoms emitting that particular wave length. As the thickness of the layer increases, however, some of the radiation is reabsorbed by the gas, leading to a departure from the simple relation just stated. This effect is termed self-absorption, which may explain a long-standing anomaly in the relative intensities of flash-spectrum hydrogen lines.

It is the analysis of these anomalous intensities that provides the number of hydrogen atoms capable of absorbing the radiation in the Balmer spectral series. The eclipse observations, consisting of a series of spectra taken as the moon covered and uncovered successive portions of the solar atmosphere as seen at the limbs of the sun, permit the number of absorbing hydrogen atoms to be determined at various atmospheric heights. Combining this data with the fact that the atmosphere must be in gravitational equilibrium, Dr. Thomas obtains a numerical value of the temperature gradient at a point in the lower chromosphere.

The particular value obtained indicates that the temperature should rise between 100,000° and 500,000° centigrade across the whole chromosphere. This figure agrees reasonably well with the two known end points: the photosphere has a temperature of some 6,000° and the corona a kinetic temperature of some 1,000,000°. Complete agreement cannot be expected, of course, in this preliminary analysis, but the method turns what was an anomaly into a means for obtaining the structure of the solar atmosphere. Harvard 1936 eclipse observations are being analyzed under the guidance of Dr. Menzel, who led that expedition, and Dr. Thomas. Within the year, it should be known whether or not the observational material will be sufficient to provide a complete chromospheric model, or, if it is not, then what supplementary observations are necessary at the next eclipse.

In Focus

WHEN the 200-inch telescope is in a nearly vertical position, the prime-focus cage carries the observing astronomer inside it to almost 70 feet above the main floor of Palomar Observatory. There he rides with the telescope tube as the star plates are exposed under his guidance; he is an integral part of this largest of all cameras, as shown by our front-cover picture this month and by the Porter drawing on the back cover.

The cage is composed of two parts. The lower portion contains the auxiliary mirrors that complete the optical train when the instrument is used as a Cassegrainian or at the coude f/30 spectrographic focus. Dr. Porter's drawing of this section appeared on the back cover of the July, 1948, issue of **Sky and Telescope.** The upper part of the cage contains the prime-focus pedestal, plateholder, guiding eyepiece, position indicators for checking the setting of the instrument, and fine-focusing controls. Details of these are shown in the May, 1948, back cover.

In the present drawing, below the observer's cage is seen the coude mirror and part of the 200-inch mirror. The lines with arrows represent paths taken by starlight and reflected from the various optical components of the telescope, but it should be noted that this is a composite drawing and that at any one time only one set of optical paths can be followed.

Located in the lower right-hand corner is the special elevator that lifts the astronomer to his lofty position for his night's work. To enter the cage, the astronomer first directs the telescope toward the south,

(Continued on page 42)

TERMINOLOGY TALKS

J. Hugh Pruett

Refraction

Did you ever momentarily fear that your best silverware was hopelessly bent as you noted its shape when it was partly under water? A straight knife seen from the side angles sharply at the water line. This is an effect due to the refraction of light. Refraction is a term derived from the Latin meaning "to break," but we often use it to mean "to bend."

In Fig. 1 is represented a glass dish nearly filled with water which has been made slightly murky with a few drops of milk. Assume, for ease of illustration, that you are somewhere in the tropics on a day when the noon sun is exactly overhead. Suppose its rays come through a small hole in the ceiling through dusty air and into the murky water. In a darkened room you can easily trace the narrow beam of light straight down through Q and O to P, without the least bending.

During the afternoon you repeat the experiment, but with the light coming

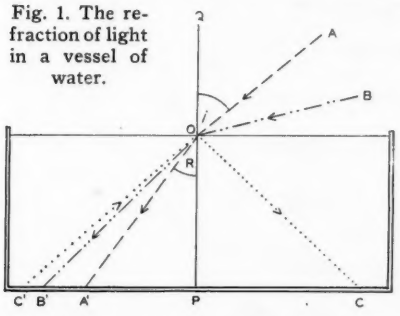


Fig. 1. The refraction of light in a vessel of water.

through a small hole in a side window. The ray AO travels straight in the dusty air, but at the water surface it bends and follows the line OA'. Nearer sunset the test is made again and the path is BOB' (with some reflection at the surface of the water).

Angles of Incidence and Refraction

The causes of refraction are discussed in books on physics and optics. When the ray from air to water meets the water perpendicularly, it is not bent. But when it touches the liquid surface obliquely, it is deviated, and the greater the value of i, the angle of incidence, the greater is the bending. The angle R between the refracted ray and the perpendicular to the surface is known as the angle of refraction.

If rays could be directed from the bottom of the dish along PO, $A'O$, and $B'O$ to the surface, outside they would trace in reverse the same paths over which the incoming rays passed. Water is denser both physically and optically than air, and light travels one third faster in air than in water. The following rules are indicated by the murky water experiment.

A light ray traveling obliquely from one medium to another in which the speed is less is refracted toward the perpendicular to the surface. When passing the boundary from the medium of lesser speed to that of greater speed, the ray is bent away from the perpendicular.

Index of Refraction

The ratio between the speed of light in air and its speed in water is, as stated above, 1.33. This is known as the *index of refraction* of water, and the definition may be applied to any substance. The index (in yellow light) for ordinary crown glass is 1.52; for medium flint glass, 1.63. These glasses slow up the light more than does water and thus they have greater refracting power. In Fig. 1, the trigonometric relation is:

Index of refraction $=$ sin i / sin R.

Total Reflection, Critical Angle

If angle $B'OP$ is made only slightly larger, the ray leaving the water lies along the surface. What occurs if this angle increases still more? It is found that no light then gets above the surface, but the ray $C'O$ reflects back into the water along OC. This phenomenon is known as *total reflection*, and the angle $C'OP$ at which this first occurs is designated the *critical angle*.

It is important to note that total reflection occurs within a denser medium at the boundary with a medium of less optical density. The following relation holds: Index of refraction $=$ 1/sine critical angle. In water, the critical angle is 48°.5.

Applications

Consider three parallel light rays from a distant source striking the convex lens in Fig. 2. Ray b strikes the surface at right angles both on entering and leaving, so is not refracted at all but passes directly to F. But ray a strikes obliquely, and is bent toward the perpendicular to the surface, xy, because the lens material is denser than air. On leaving, it bends according to rule away from the perpendicular $x'y'$. Because of the lens construction, double convex, both bends are in the same direction to send the ray on to F. The same occurs at c and at points between a and c to concentrate all the light in the beam at F, the focal point.

A totally reflecting prism is sometimes

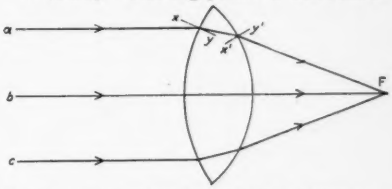


Fig. 2. The refraction of light through a double-convex lens.

used in place of the diagonal flat for the secondary in reflecting telescopes, or at the eyepiece end of refractors for ease of observation when an object at a high altitude is to be observed. The right-angle prism in Fig. 3A is set so that rays from the objective (lens or mirror) strike its surface perpendicularly (or nearly so), thus allowing them to pass through the glass and contact the hypotenuse at about 45°. Since the critical angle of crown glass is only 42°.5, all the light is reflected internally and out of the other surface of the prism to the eyepiece. Compare this arrangement with the sun telescope prism shown in Fig. 3B, where the reflection from the unsilvered outside surface of the prism is very weak, thereby serving to cut down the intensity of the solar rays.

Another important application of refraction is that produced by the earth's atmosphere on light reaching us from the heavenly bodies. On its way in, this light passes through air of ever-increasing density, which causes the rays to bend toward the perpendicular. There is no effect in the zenith, but refraction increases toward the horizon, where a star is given an apparent lift of 35 minutes of arc. This raises the entire sun or moon over the skyline before even their upper edges would appear were our world without its airy covering.

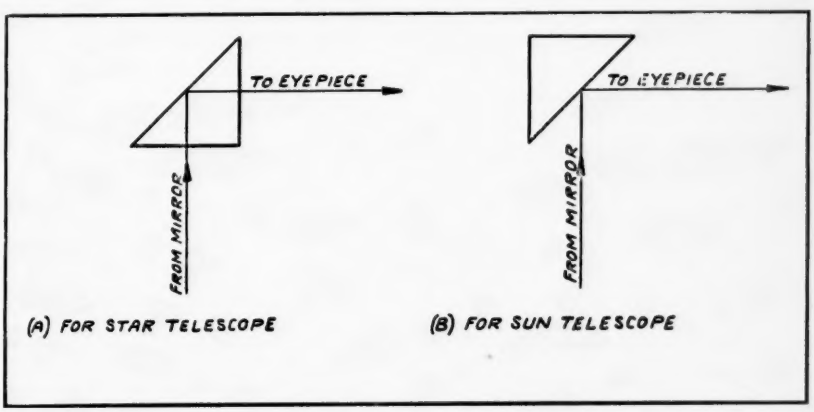


Fig. 3. Total and ordinary reflections from the same prism.

NEWS NOTES

By Dorrit Hoffleit

PANCAKE THEORY

The latest theory of the origin of the earth and other planets and their satellites, by Dr. Gerard P. Kuiper, of Yerkes Observatory, University of Chicago, is a modern version of the theory proposed by Immanuel Kant in 1755, who speculated that the planets and the sun originated from a single whirling mass of gas. Kuiper shows that gas and dust forming a nebula around the sun would have contracted to a thin "pancake," much like the rings of Saturn, in the plane of the present planetary orbits. The thickness of the pancake would have been about one per cent of its diameter and its mass about half that of the sun. When its density had reached a critical value, the pancake broke up into a number of whirling eddies which shrank and finally condensed into planets and satellites.

The growth of the planets, according to this hypothesis, would have taken only a few thousand years, and that of their satellites about a hundred. Saturn's rings failed to condense into moons because they were too close to Saturn.

One item in the University of Chicago news release concerning the theory may come as a surprise. In mentioning that the earth and moon should probably be considered as a binary planet, the release states, "The condensation products which formed the earth were collected largely in solid form, 'hailing' down in the manner first conceived by Chamberlin and Moulton. The moon preserved in her pockmarked face the fossil craters due to the impacts." On the earth, the pockmarks have largely disappeared, "except in a few cases, such as the meteor crater in Arizona"! Is not this a challenge to those who would determine the age of Meteor Crater and the Kaibab limestone in which it occurs?

WHICH ARM IS THE NEARER?

A letter to the British journal *Observatory* suggests the use of Cepheids and the period-luminosity relation for testing the age-old quandary as to which arm, the north-preceding or the south-following, in the spiral in Andromeda is the nearer. G. de Vaucouleurs, of the Institut d'Astrophysique at Paris, points out that the two arms must differ in distance by some three per cent of the distance. Thus, the magnitudes of similar stars must also differ, by 0.06 magnitude from this cause alone and by more because of the probable absorption by dust and gas in the galaxy itself.

The scatter in the period-luminosity diagram is about 0.8 magnitude; the average of 20 stars would be needed to get the probable errors down to 0.03 magnitude. As yet only a dozen Cepheid variables are known in the south-following part of M31, and only two in the north-preceding arm. This is obviously a job for large telescopes.

NEW TROJAN ASTEROIDS

Recently, Dr. K. Reinmuth, of Heidelberg Observatory, has discovered two new members of the Trojan asteroids, which are of especial interest because of their unique association with Jupiter. They stay at nearly the same distances from Jupiter and the sun, circulating about either of the points of the planet's orbit that together with Jupiter and the sun form an equilateral triangle. Since they are so far away, these planetoids are all fainter than the 12th magnitude, 14.7 and 14.8 in the case of the new objects. Further observations are needed with large instruments in order to follow such faint asteroids, for which positions and motions for September and October are given on Harvard Announcement Card 1042, issued November 2, 1949.

In the CURRENT JOURNALS

Double Stars, by Otto Struve, *Scientific American*, October, 1949. The large number and various types of these companions in space are a problem to astronomy. The author's theory relates them to the evolution of both stars and planets.

The Story of Aids to Navigation, by Thomas Coulson, *Journal of the Franklin Institute*, October, 1949. "The science of navigation has advanced to that stage of refinement, with mechanical aids and complex apparatus, that we are prone to forget there was a time when men sailed over wide stretches of ocean without aid from any of these devices."

Modern Computing, by R. D. Richtmyer and N. C. Metropolis, *Physics Today*, October, 1949. "The intricacies of automatic computing methods have been popularized by pictures, visual and verbal, of complicated wiring diagrams, great banks of electron tubes, and dramatic control boards, as well as by certain romantic analogies between machines and the human brain. There remains, however, a need for defining the limits of computing machine operation, as well as its promise."

Radio Astronomy, by J. S. Hey, *Monthly Notices* of the Royal Astronomical Society, Volume 109, No. 2, 1949. The beginnings of radio astronomy came some years before the war and the historical development is outlined; but only in recent years have techniques advanced and knowledge increased sufficiently for the potentialities of this new science to be adequately appreciated.

OBSERVATORIES INVITED TO AUSTRALIA

Mt. Stromlo, the site of the Australian Commonwealth Observatory, at an altitude of 2,600 feet, has natural advantages scarcely equaled by other locations, including excellent seeing conditions. This will be the site of the Commonwealth's new 74-inch reflector. The observatories of Columbia, Yale, Leiden (Holland), and Uppsala (Sweden) universities have been invited to share the advantages of Mt. Stromlo. The first three of these already have southern stations, all at Johannesburg, South Africa, but they are affected by the smoke and haze from the heavy industry of the city and would find the change of scenery advantageous. Uppsala has not before had a southern station.

MEDAL FOR METEOR STUDY AWARDED

The National Academy of Sciences, at its meeting in Rochester on October 24th, presented its J. Lawrence Smith medal to Dr. Fred L. Whipple, of Harvard Observatory. The fund for this medal was established in 1884 to encourage research on meteors, and in the past it has been awarded only three times: in 1888 to H. A. Newton for investigations on the origin of meteors; in 1922 to G. P. Merrill for work on the character of meteorites; in 1945 to Stuart H. Perry for studies on the metallography of meteoric iron.

The present award to Dr. Whipple is "in recognition of his acknowledged leadership in the field of the motions and nature of meteoric particles in the earth's atmosphere, and especially for his derivation of the variations of air temperature with altitude based on his studies of meteors, and for his investigation of other upper atmosphere phenomena, the results of which correspond closely to the values obtained up to heights of 65 kilometers by V-2 rockets."

At the time of the presentation of the medal, Dr. Whipple delivered a paper on micrometeorites, tiny bodies that are sufficiently small to enter the earth's atmosphere without being damaged by encounter with the air. Their dimensions are of the order of a few microns, and they are able to radiate the heat of friction with the atmosphere so rapidly that they never are heated to their melting points, thus settling to the earth as fine dust.

Dr. Whipple suggested that micrometeorites may be the only true debris from comets that reaches the earth, and he proposed an intensive search for them. Already, other workers have been examining melted snow from remote polar regions, and it is possible micrometeorites may exist in deep oceanic sediments and in stratified rocks, where they would give evidence of conditions in the solar system in ages long past.

DECEMBER ASTRONOMY MEETINGS

The 82nd meeting of the American Astronomical Society will be at the University of Arizona in Tucson, on December 28-31. Two symposia are scheduled, one on Thursday, December 29th, on "Current Programs of Schmidt Telescopes," with papers from Warner and Swasey, Harvard, Palomar, and Tonanzintla observatories. The following day, "Some Problems of the Dwarf Stars" will be discussed by Drs. A. H. Joy, G. E. Kron, G. P. Kuiper, W. J. Luyten, H. F. Weaver, and R. E. Wilson. The presidential address of Dr. Otto Struve will also be delivered on December 30th. Three sessions for papers are scheduled. Headquarters will be at Yuma Hall and the Steward Observatory.

In New York City on December 28-29, Section D of the American Association for the Advancement of Science will meet at the time of the 116th meeting of the AAAS, December 26-31. In addition to meetings Wednesday afternoon and Thursday, Section D will meet with the Institute of Mathematical Statistics and the American Statistical Association on Friday morning, the 30th, for a session on "Statistical Methods in Astronomy," with Dr. Walter Bartky, University of Chicago, as chairman. Papers will be given by P. van de Kamp, B. J. Bok and Joost K. de Jonge, Elizabeth L. Scott, and H. Hotelling.

On Thursday afternoon, Dr. D. B. McLaughlin, of the University of Michigan Observatory, will give the address of the retiring vice-president of Section D, "Problems in the Spectra of Novae."

The Wednesday session is at 1:30 p.m. in the Hotel McAlpin ballroom, Dr. McLaughlin presiding. Thursday meetings are at the Governor Clinton Hotel, with Dr. Harlow Shapley presiding in the morning, and Dr. L. Spitzer, Jr., in the afternoon. The Friday joint session is also at the Governor Clinton Hotel.

MOUNT WILSON ASTRONOMER RETIRES

The members of the staff of Mount Wilson Observatory recently honored Dr. Roscoe F. Sanford at a testimonial dinner in Pasadena on the occasion of his retirement. Dr. Sanford has been at Mount Wilson since 1918. Prior to that he was associated with the Lick Observatory, where he earned his Ph.D. and was a member of the Mills expedition to Chile from 1911 to 1915. This summer we found Dr. Sanford enjoying his work on the spectra of red stars, which we hope he will carry on in retirement.

NEW INSTRUMENTS FOR INDIA

One day in October the prime minister of India, Pandit Jawaharlal Nehru, paid a brief call at Harvard, where he discussed with Dr. Harlow Shapley and others the future of India's observatories. A new Schmidt-type telescope is planned for Allahabad University Observatory in the north and a solar coronagraph for Kodaikanal Solar Observatory in southern India. Dr. A. C. Banerji, of Allahabad, is being sent to America to get the first of these projects under way, while Dr. A. K. Das will come to work out the solar project.

MEMORIAL PLANETARIUM

An address by I. L. Thomsen before the New Zealand Astronomical Society has been published in the journal *Southern Stars*. He makes a strong plea for a planetarium as a suitable war memorial. Instead of duplicating the statuary of the past, why not make the memorial a living one that would foster "the contemplation and attempted understanding of the universe"?

DARWIN LECTURE

Dr. Otto Struve, of Yerkes Observatory, delivered the George Darwin lecture at the meeting of the Royal Astronomical Society (London) in October. His topic was "Spectroscopic Binaries." The George Darwin lectureship fund was established in 1926 by Sir James Jeans, who presented the Royal Astronomical Society with the necessary funds for an annual lectureship. The lecture is to be on some subject of interest to astronomers and preference is to be given, in selecting the speaker, to someone normally resident outside the British Isles.

THE SPECTRUM OF NOVA SCUTI 1949

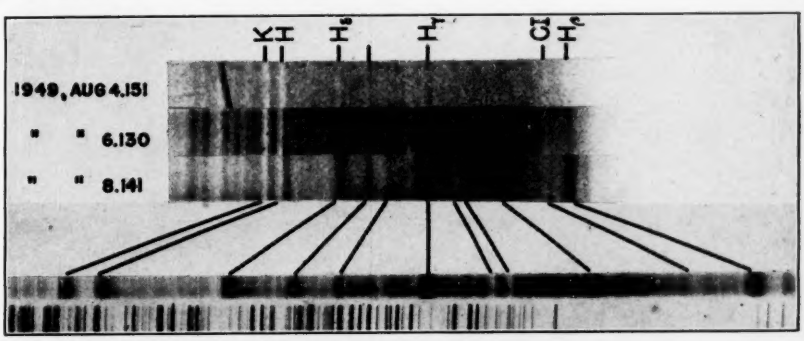
THE TELEGRAM announcing the discovery of Nova Scuti 1949 on July 31.95 was received at the McDonald Observatory during the day of August 3rd. On the night of that day, in spite of considerable cloudiness, the existence of the nova was confirmed by visual inspection of its field, and it was estimated to be as bright as the neighboring star HD 175993 (8.5). At this time there was attached to the 82-inch reflector the small-dispersion spectrograph with all-quartz optics of the Institut d'Astrophysique in Paris, France, specially designed by Dr. D. Chalonge for spectrophotometric work in the continuous spectrum of stars. It was decided, therefore, to obtain a series of spectrograms of the nova for spectrophotometric purposes. The measure and reduction of the plates will be attempted later, but at this time it may be of interest to give some general qualitative remarks about them.

The spectrogram obtained on August 4.2 shows an absorption spectrum that resembles that of an early **F** supergiant, with the absorption lines in general somewhat weaker. The group of lines of neutral carbon at wave lengths 4762, 4771, 4776 (CI on the illustration), is noticeable by the great intensity. Due to cloudy weather the nova was not observed again for several days, when it showed conspicuous red emission edges. On successive nights the strength of the emission spectrum continued to develop steadily, while the light of the nova first remained approximately constant for four nights and then started to decrease. The last spectrogram illustrated was obtained with the Cassegrain spectrograph, when the nova appeared to be 0.5 magnitude fainter than HD 175705.

It is perhaps of interest to stress the similarity of this object with Nova Herculis 1934. The reported photographic magnitude of Nova Scuti at discovery was 9.6, but since this star is in a region heavily obscured, it is very likely that the visual magnitude at maximum was not far from 8.0. Using McLaughlin's terminology, we may say that on August 3-4 the nova was in the stage of "principal absorption spectrum," which immediately follows maximum light. In the case of Nova Herculis, this stage was reached on December 23-24, 1934, one day after maximum light. To make the similarity more complete, we further may point out that the high-dispersion spectrogram illustrated, obtained 13 days after maximum and about 1.5 magnitudes below maximum light, strongly resembles the spectrum of Nova Herculis on January 5, 1935.

V. KOURGANOFF,
R. CANAVAGGIA,
and G. MUENCH

Aug. 25, 1949



McDonald Observatory spectra of Nova Scuti 1949. The lowest, of high dispersion, was taken August 13.188. Below it is a reference spectrum.

1948-49 Among the Variable Star Observers

DURING the 12 months ending September 30, 1949, the peculiar variable star SS Cygni reached maximum brightness seven times, and five maxima of SS Aurigae were recorded, together with two for U Geminorum, by members of the American Association of Variable Star Observers. R Coronae Borealis, after dropping to the 14th magnitude, the faintest in many years, began a steady rise and was brighter than the 9th magnitude at the end of September, where a slight halt in its rate of brightening occurred. S Apodis, the far-southern variable of this same type, was still faint, after more than a year, hovering between magnitudes 12 and 13, with little sign of a rapid rise to maximum. RY Sagittarii was at maximum throughout the year, and this star showed further evidence of a short-term periodicity. SU Tauri, the fourth of the R Cor Bor type of variable, was also at full maximum, but AAVSO members have been alerted to maintain close watch to insure observation of its fading to its next minimum. Dr. George H. Herbig, of the Lick Observatory, is anxious to be notified when any of these stars begins to fade, in order that he may obtain spectra during the changes in brightness.

The facts above are only a sample, taken from the final report by Leon Campbell, retiring recorder of the AAVSO, of the kind of information that may be gleaned from the 50,006 observations of variable stars made by members of this society of amateur astronomers in a single year. Fortunate it is that in his retirement Mr. Campbell expects to continue his detailed discussion of the light fluctuations of some 400 long-period and peculiar variable stars that have been under observation for several decades by members of the association. And, as indicated by the case of the R Cor Bor stars, the work of amateur observers is essential to professional astronomers interested in variable stars.

The monitoring of AAVSO observations has now become the task of the new Pickering memorial astronomer, Mrs. Margaret W. Mayall, who was elected AAVSO recorder to succeed Mr. Campbell at the 38th annual meeting of the society, held at Harvard College Observatory, October 14-15, 1949. Mrs. Mayall will occupy the AAVSO headquarters in Building A at Harvard, and Mr. Campbell will maintain his desk in an office in Building C.

The year's observations were contributed by 141 observers, headed by Cyrus Fernald, Wilton, Me., with 7,654 estimates of stars' brightnesses. Second most assiduous observer was R. P. de Kock, Capetown, South Africa, with 5,210 observations; third was Paul Ahnert, Sonneberg, Germany; fourth was Leslie C. Peltier, Delphos, Ohio. For 31 years Mr. Peltier has made a report to the AAVSO every month. Twenty-two observers contributed 75 per cent of the year's observations. The 56 observers who each made less than 50 estimates nevertheless made an important contribution as some of their estimates helped to fill in gaps that might otherwise have occurred at a crucial point in a star's fluctuations.

No less assiduous, and of very immediate practical importance are the observations of the sun made daily by the solar division of the AAVSO, which has 117 observing and 68 research members. During the year 7,594 solar observations were made, bringing the grand total since the establishment of the solar division to 60,674. Neal J. Heines, Paterson, N. J., chairman of the division, was elected president of the AAVSO for the coming year. He succeeds David W. Rosebrugh, of Waterbury, Conn.

In his report to the meeting at Cambridge, Mr. Heines listed the American relative sunspot numbers for four months: May, 147.4; June, 154.5; July, 153.6; and August, 163.7. Sunspot areas (which some astronomers believe may be a better index of solar activity than sunspot numbers) for the same period were 1,415, 1,627, 1,736, and 2,295, respectively. The areas are corrected for foreshortening and are expressed in millionths of the sun's hemisphere. In the *Solar Division Bulletin* for November, predictions of the smoothed monthly sunspot numbers for six months are given as: October, 110; November, 107; December, 104; January, 100; February, 96; March, 90; which reflects the gradual decline expected to take place in sunspot activity.

The solar division is actively engaged in a number of projects, including sunspot counts for the National Bureau of Standards, the study of solar granulation and color in sunspots, the foreshortening of sunspots, the observing of migratory birds in flight across the sun and moon, sunspot area measurements, and the observation of solar prominences with filters now under construction. The solar division's latest project, now organized, provides for the monthly reporting of observations of the aurora.

Mrs. Margaret Beardsley, Springfield, Vt., reported for the occultations committee, working under the AAVSO. Observations made in 1948, 82 in number, have been turned over to Dr. Dirk Brouwer, Yale University Observatory,

The American Association of Variable Star Observers, Cambridge, Mass., October 15, 1949. Photo by Ralph H. Hutchins, Jr.

to be sent to England for reduction, and 69 reports were received in 1949 up to October 1st. An instruction pamphlet on occultation timing is available from Mrs. Beardsley; observations are particularly needed from points in the Mountain zone of standard time.

The Saturday evening annual dinner was marked by a number of tributes to Mr. Campbell, now honorary recorder of the AAVSO. A large number of old and new friends attended the meeting to pay him their respects, and from all over the world letters had been sent by friends and admirers. These were collected into a souvenir book which was presented to Mr. Campbell, and at the dinner excerpts from the letters were read. Past officers and old friends of the association gave short talks.

In accordance with custom, Dr. Harlow Shapley listed his 10 astronomical highlights of the year. The first was the great activity in the big-mirror field: Lick Observatory acquired a 120-inch blank from California Institute of Technology; the Astronomer Royal received a 98-inch blank as a gift from the University of Michigan to England's Isaac Newton memorial telescope; 74-inch telescopes were ordered for Mt. Stromlo Observatory in Australia, for the Helwan Observatory in Egypt, and for the St. Michel Observatory in France. Somewhat smaller instruments will be constructed at Uppsala and Stockholm, in Sweden.

As another highlight, Dr. Shapley listed the setting into operation of the 200-inch Hale telescope and the 48-inch Schmidt on Palomar Mountain, and the final completion of the 74-inch reflector at Pretoria, South Africa. Baade's finding of the asteroid that goes inside Mercury's orbit, using the 48-inch Schmidt; the discovery by Kuiper of the second satellite of Neptune; the new Whipple comet theory; Luyten's nearby pair of extremely dwarf red stars; Eggen's work on colors of stars with the photoelectric photometer, were also listed. A veritable flood of interesting theories on cosmic rays, mostly involving magnetic fields in space, point to the possibility that cosmic rays are of solar system origin.

Radar observations of the moon during the April and October lunar eclipses by W. W. Salisbury, at Cedar Rapids, Iowa, indicate no change in the moon's radio emission during totality. As the radio energy is believed to emanate from a level a short distance below the moon's surface, the great insulating effect of the surface layers is indicated, which in turn may confirm the belief that the moon is covered with a non-conducting layer of dust. Dr. Shapley listed lastly the observations by Haro in Mexico of bright lines in the spectra of objects in the Andromeda nebula heretofore tentatively classified as globular clusters. C. A. F.

Amateur Astronomers

AMATEUR ACTIVITIES FROM HERE AND THERE

In addition to some eclipse observing parties, star observing sessions for the public have been held in many cities this past summer and fall. Perhaps the example of the star party held in Cleveland during the convention of the Astronomical League inspired many groups to this activity. Space does not permit **Sky and Telescope** to carry detailed reports of all these star parties.

In California, the Sacramento Valley Astronomical Society planned a star party at the grammar school in Lodi, 20 miles away from Sacramento, for the evening of October 29th. Two reflectors and two refractors were to be set up. Mr. Paul Steele was to speak on constellations beforehand in the school auditorium. The SVAS took its usual part in the California State Fair early in September.

From Portland, Ore., H. J. Carruthers reported that in the very near future it was expected to have a Spitz planetarium in operation in the local museum of science and industry, which is operated by the Oregon Museum Foundation, Inc. Astronomical activities in this city are carried on by two groups, the Portland Astronomical Society and the Portland Amateur Telescope Makers and Observers.

In Cincinnati, Ohio, a display in a Sherwin-Williams paint store was one means for publicizing a star party that was held on August 26th. An estimated 2,000 persons attended this third such event sponsored by the Cincinnati Astronomical Association. This society now has a membership of well over 100 persons. The exhibit included an 8-inch reflector, with an adjustable iris diaphragm for stopping down to suit seeing conditions; a 6-inch reflector; a moon montage; astronomical photographs and paintings.

The Yakima Amateur Astronomers had a display in the Central Washington Fair, held at the end of September. Some of the exhibits were available from the exhibit at the Northwest regional convention of the Astronomical League early in the month. The astronomical corner had to be shared with a model train builder, but next year the society hopes to make use of the whole corner space.

THIS MONTH'S MEETINGS

Buffalo, N. Y.: For the December 7th meeting of the Amateur Telescope Makers and Observers of Buffalo, Raymond Missert will speak on "Lunar and Planetary Work for Amateurs." William C. Oberem, treasurer of the Astronomical League, will tell of "Activities of the Astronomical League — Past and Present," on the night of December 21st. Meetings are at the Science Museum, 8:00 p.m.

Cambridge, Mass.: On December 9th, at a joint meeting of the Bond Astronomical Club and the Amateur Telescope Makers of Boston, John W. Streeter, Vassar College Observatory, will speak on "The American Tradition in Astronomy — 1659 to 1949." The meeting will be at 8:15 p.m., at Harvard College Observatory.

Chicago, Ill.: The Burnham Astronomical Society will meet on Tuesday, December 13th, 8:00 p.m. at the Chicago Academy of Sciences auditorium. Members will report on the December evening sky, on observations and telescope making. Wagner Schlesinger, director of the Adler Planetarium, will speak on the "Story of the Constellations."

Detroit, Mich.: The Detroit Astronomical Society will show films on the moon and on atomic energy at its Sunday, December 11th meeting at 3 p.m. in State Hall, Wayne University (entrance on 2nd Ave.).

Geneva, Ill.: The Fox Valley Astronomical Society will hold its Christmas party in the Geneva City Library on Tuesday, December 6th, at 8 o'clock, when Harry R. Rymer, from Dearborn Observatory, will speak on "Personal Experiences with the Byrd Antarctic Expedition, 1947-48."

Indianapolis, Ind.: A "Review of 1949" will be held by the board of officers of the Indiana Astronomical Society at its December 4th meeting in Cropsey Hall at 2:15 p.m.

Los Angeles, Calif.: The Los Angeles Astronomical Society meets at the Griffith Observatory on December 13th at 7:45 p.m. Don O. Hendrix, of the Mount Wilson optical shop, will speak on "Constructing a Schmidt Camera."

New York, N. Y.: "Seismology and the Weather" will be the subject of the Rev. J. Joseph Lynch, S. J., of Fordham University, at the meeting of the Amateur Astronomers Association on December 7th, at 8:00 p.m. in the American Museum.

On Friday, December 2nd, at 8 p.m., the Junior Astronomy Club will have for its speaker Willy Ley. His topic will be, "Upper Atmosphere Rocket Research and Astronomy." The meeting is at the American Museum of Natural History.

Pittsburgh, Pa.: On Friday, December 9th, at 8:15 p.m. at the Buhl Planetarium, Leo Scanlon will present to the Amateur Astronomers Association of Pittsburgh a program on "Highlights of an Amateur's Observations."

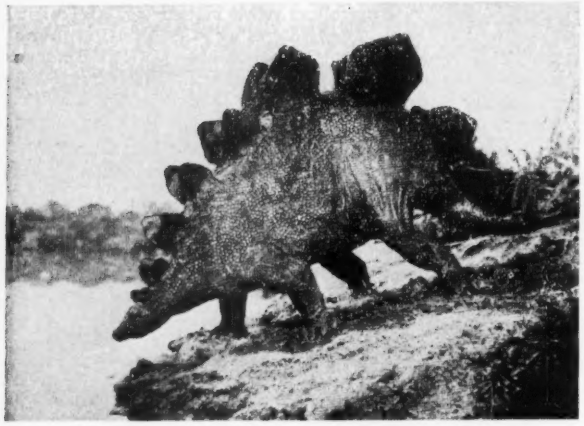
Portland, Ore.: At the meeting of the Portland Astronomical Society on December 7th, 7:00 p.m. in the Central Public Library, C. A. Wood will speak on "Peculiarities of Light."

Sacramento, Calif.: The December 6th meeting of the Sacramento Valley Astronomical Society will be at 7:45 p.m. at Sacramento Junior College. Dr. Oliver J. Lee will speak on "Strategy and Tactics in Astronomy." The second annual Christmas party of the SVAS will be on December 17th at the Clunie Clubhouse.

Stamford, Conn.: On December 16th the Stamford Amateur Astronomers will hear Dr. R. M. Scott, of the Perkin-Elmer Corporation, speak on "Variable Stars, the Yardsticks of the Universe," at 8 p.m. in the Stamford Museum.

GALACTIC ROTATION AND COSMIC

BY HARLOW SHAPLEY, *Harvard College Observatory*



Stegosaurus, an armored dinosaur of the most recent "cosmic summer." From a model by Vernon Edwards; photo by Camerascopes, Ltd., London.

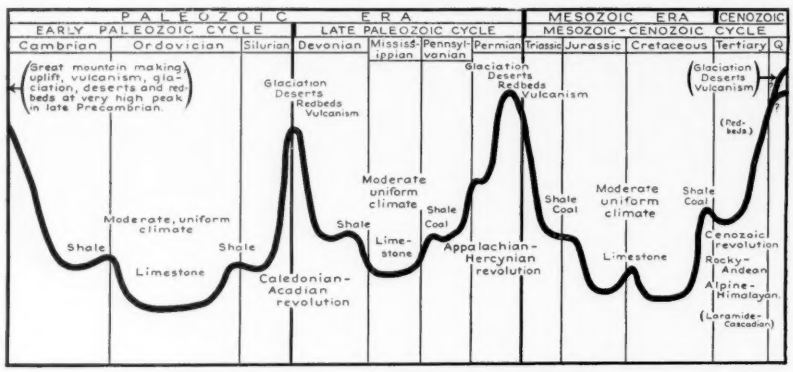
FIVE OR SIX hundred million years ago, by the radioactivity clock, there was a pronounced emergence of the continental areas. Glaciers scoured the rocks on various parts of the earth's surface. It was, in a sense, a long-enduring geological winter — a season of tens of millions of years, when the primitive evolving plants and animals kept themselves to the equable temperatures of the oceans and to the shallow land-bordered seas. That was in the concluding millenia of the pre-Cambrian period. Again, toward the end of the Silurian period and the beginning of the Devonian, glaciation was widespread; and twice thereafter it has been conspicuous — at the end of the Paleozoic era and at the present time. These four ice epochs dominate the climatic records for the past half billion years.

Curiously enough, these major geological "winters" are spaced at intervals of somewhat less than 200,000,000 years. The intervening major warm periods in the Ordovician, the Carboniferous, and the late Mesozoic eras are similarly spaced. The accompanying diagram is taken from Snider's *Earth History*.

The chronology of the major climatic rhythms that have occurred since the fossil plants and animals began keeping the record is briefly recalled at this time in order to point out a remarkable cosmic coincidence.

The best determinations of the distance of the sun from the galactic center give a value of 10 kiloparsecs, or perhaps a little less — about 30,000 light-years. Since the motion of the sun and neighboring stars is in a direction in the Milky Way practically at right angles to the direction to the center, we can assume that the sun's orbit about the nucleus in Sagittarius is roughly circular. From the accepted values of distance and speed we can then compute that the time for one revolution (a "cosmic year") is approximately 200,000,000 years.

Ignoring the temptation to interpret otherwise, we accept tentatively as only coincidental the rough similarity of the length of the cosmic year to the duration of a major terrestrial climatic cycle. A sufficient reason for caution in associating causally galactic rotation and climatic cycles lies in the fact that the "winters" of early Cambrian, early Devonian, late Permian, and Pleistocene times were all epochs of great uplift of continental areas, and the intermediate "summers" were times of maximum subsidence, with the warm shallow seas covering much of the eroded land areas. The long-scale climatic changes can therefore be directly attributed largely to the effects of land elevation on ocean currents and air movements, rather than to the position of the sun and the earth in the rotating galaxy. Presumably it is too farfetched to suggest that galactic position could incite major crustal movements, even though it might provide variety in solar radiation and terrestrial temperatures.



The average continental level through half a billion years. This and the pictures on this page are reproduced from Snider's "Earth History."

Looking at the chronological details, we note that, at the time a million centuries ago when the Cretaceous dinosaurs dominated the zoology of the Mesozoic era, the earth, sun, planets, and neighboring stars were in the trans-Sagittarius part of the Milky Way, 50,000 to 60,000 light-years distant across the nucleus from our present position. It was cosmic summertime. The mammals were still primitive; primates nonexistent. Homo was to be a development of the last "week" of that cosmic year, and his semi-civilization to be an experimental phenomenon of the last quarter hour.

A restoration of a late Devonian forest, showing horsetails, club mosses, and tree ferns. Field Museum photograph from Snider's "Earth History."

SEASONS

The solar system also was in the trans-nucleus vicinity three million centuries ago, on a trip in the preceding cosmic year, when the horsetails, club mosses, and tree ferns were preparing the Carboniferous coal beds; and one trip earlier our planet was in the same region during the long warm millenia of the Ordovician period when the primitive trilobites were still dominant.

During the Silurian and Permian cosmic winters, the solar family moved in the same galactocentric longitudes as now. Our planet and its evolving biology were then as now on the Andromeda nebula side of our galactic system.

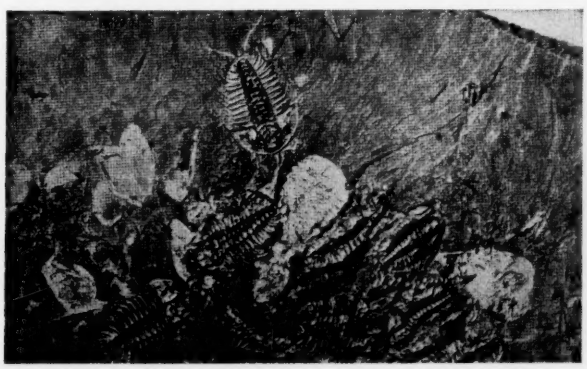
Some parts of the sun's course around the galactic nucleus are undoubtedly more infested with interstellar dust and gas than other sections, unless, as is unlikely, the interstellar material revolves precisely at our speed. We have long been aware of the high probability that cosmic dust clouds have been one of the contributors among the several factors causing climatic change in the geological past. My discussion of this subject in 1920[1] has been generally ignored, probably because we could not say then, as we cannot definitely say now, in what direction, or by what amount, the insolation of the earth and its mean surface temperature would be changed by a transit of the solar system through cosmic dust-and-gas clouds.

The problem is complicated by the fact that not only the earth's atmosphere but also the sun's radiation would be disturbed, in quantity and quality, by the passage of sun and planets through nebulous regions. Recently, the consideration of the effect of cosmic dust on terrestrial climate has been revived[2]; but the large localized climatic effects resulting from mountain uplift have been so clearly significant throughout the past half billion years that a hypothesis of hot and cold spots in the galaxy is interesting but not necessary to account for major climatic changes.[3]

The great starclouds in the Sagittarius region of the Milky Way. Thirty thousand light-years away in this direction lies the nucleus of the galaxy, arcund which the sun revolves once in about 200 million years.

We can reasonably assume that the period of rotation of the galaxy is neither irregular nor rapidly changing in length. Therefore, in pre-Cambrian eras the galaxy must have rotated many times, on a fairly definite schedule. How about the mountain building and climatic rhythms of those times? Was the long cycle then in operation? Naturally, the geological evidence is scanty, but there were undoubtedly in Proterozoic and Archeozoic eras several great uplifts and subsidences. The records appear clear on that point. To determine their spacing in time, however, is still beyond us. And Professor R. A. Daly has pointed out to me that the post-Cambrian climatic cycles are not precisely spaced, and the records of Paleozoic glaciation are still fragmentary.

Before this thought-provoking rough relation between galactic rotation and cyclic climates is written off as purely coincidental, it would be of great interest (I remark hopelessly) to obtain a record of the paleoclimatology of Mars, for on that planet the climatic effects from the cosmic dust clouds are probably not so seriously confused by orogenic movements.



The fossils of trilobites, preserved in hard shale from British Columbia, that thrived three "cosmic summers" ago at the end of the Cambrian period. U. S. National Museum photograph.

[1] **Journal of Geology**, *29*, 502, 1921.

[2] Hoyle and Lyttleton, **Proceedings**, Cambridge Philosophical Society, *35*, 405-415, 1939; **Sky and Telescope**, VIII, 6, November, 1948.

[3] Since writing these notes, I find Wm. T. M. Forbes (**Science**, 74, 294, Sept. 18, 1931), in commenting on climatic cycles and galactic rotation, suggested that uneven dust clouds between us and the galactic nucleus alternately block and reveal the stars therein, affecting the heat supply from these distant stars. The radiation from stars, however, appears to be completely ineffective as a source of terrestrial climatic change compared with uplift, vulcanism, or even solar variations.

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BOOKS AND THE SKY

SKYSHOOTING

R. Newton Mayall and **Margaret Mayall.** The Ronald Press Company, New York, 1949. 174 pages. $3.75.

HAVE YOU BEEN thinking of combining your vacation in the summer of 1954 with the solar eclipse which starts in Nebraska and passes northeastward over the Hudson Bay area? Without question you would take a camera or several along to make a series of pictures during those precious moments, but would you have any idea what the exposures should be?

Skyshooting is written for anyone with a camera who wants some of the fun of photographing the heavens. Based on the authors' own experience as skyshooters, it tells the layman what there is to photograph and provides him with explicit and understandable information as to how the heavenly wonders can be photographed, both with and without the aid of a telescope. The book contains 59 illustrations, the majority of them by amateurs, to illustrate the type of work that can be done with the simplest of equipment. There is also a sampling of photographs by large observatories to show how the amateur's work compares with that of the professional astronomer.

The first chapter, "Looking It Over," suggests that you take any camera and a tripod, and make star trails or photograph meteors and aurorae; or other objects with a simple guided camera. Even if you do not own a camera, you can make one from grandma's 3-inch reading glass. While you are making these beginner's pictures you also get a schooling in the fundamentals of focal length, angle of the lens, aperture, and other basic information which will be so useful in later endeavors.

So little is known about the northern lights that the professional astronomer is eager to receive any help camera fans can give him. If you own a candid camera with a fairly fast lens you are exceptionally well equipped for this type of scientific research. Excellent photographs can be made at a fraction of a second exposure at f/4.5, on some of the brighter displays. Descriptions of all the basic types of auroral forms are given. Remember that aurorae cover vast areas of the continent and no duplication will exist between your work and that of the professional, because he cannot obtain the data over so widespread an area as can the amateurs in a co-operative program.

To photograph the stars, some simple form of mounting with a small guide telescope should be provided for the camera. Then one can follow the motions of the stars and make each star image appear as a pinpoint of light on the film. Your camera can be used to show magnitude scales, to determine magnitudes of variable stars and other objects. Dealing with variable stars, one is really concerned more particularly with the brightnesses of the stars as they appear on photographs. Here is the place to get acquainted with photographic magnitudes, mentioned earlier in the book. Spectral classifications enter at this point and are explained without a mathematical equation. The taking of photographs, the search for variable stars and new stars on the negatives, and what to do with such data or discoveries are handled clearly but simply.

A great deal of photographic information is presented for taking pictures of the sun and moon, whether individually or in combination during solar and lunar eclipses. Beautiful pictures of sunspots can be made with a small telescope although you might be without a driven mounting.

In order to avoid many of the pitfalls of the beginner, the authors outline a few methods of procedure that have been tried and tested, in development of your own films, printing, and enlarging. Following the simple rules laid down you are sure of success in everything from the loading of the plateholder or film to the showing of your enlarged prints.

Mountings are discussed, and a series of photographs show the basic types, both with and without mechanical drives. Since circles are an asset on any mounting, their construction and use are covered in two short chapters. Circles are of great aid in the efficient operation of the camera, especially in setting up on an object invisible to the eye. Finding sidereal time, using it, and making use of the setting circles enable one to shoot the stars with the least amount of effort.

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The authors stress the importance of keeping good records, records that really make your photographs valuable to yourself and to astronomy, especially in the event the film might contain asteroids, novae, variables, or comets. Every exposure made should be entered in a simple record book, several forms of which are discussed, and after development each negative should bear the same number as the exposure in the record book.

The appendix lists the various active amateur astronomical organizations, planetariums, and observatories. A list of objects includes variable stars, clusters, nebulae, galaxies, rich star fields, and 100 selected stars. The amateur's library is not forgotten; handbooks, general reference books, and astronomical magazines for the amateur are listed.

Skyshooting is written in a very informal style, almost devoid of mathematical formulae. It includes ample background material on astronomy, on telescopes, telescope mountings, and other necessary or desirable equipment. With the aid of this book one can get the proper start as a skyshooter, know where he is going, and be reasonably sure of success. The book is also unique in that each chapter is closed with a short summary of the equipment, the film, and the exposure for the object in question.

EDWARD A. HALBACH
Milwaukee Astronomical Society

MUST WE HIDE?

R. E. Lapp. Addison-Wesley Press, Inc., Cambridge, 1949. 182 pages. $3.00.

THE ANSWER to the question, "Must we hide?" from the atomic bomb is sought by Dr. R. E. Lapp in his book of this title. His thesis is to prove that the answer is no. He has assembled quantities of evidence to support his belief that the atomic bomb is no more terrible a weapon than those more conventional forms of destruction used throughout the last war.

The author's first task is to show the reader that the atomic bomb in general is less damaging than, for example, a fire bomb raid, and he cites such examples as "One raid set [Hamburg] ablaze and thousands perished in the fire storm that followed. More died at Hamburg than were killed at Nagasaki by the atomic bomb." "Even the later atomic disaster at Hiroshima was less terrible and less destructive than the Tokyo fire raid. . . . The holocaust burned itself out, leaving devastation awesome to behold. Almost 15 square miles of the world's fourth largest city had been wiped out. This and a few subsequent minor raids took a toll of almost 100,000 lives in the Tokyo area and there were almost as many injured as dead."

Dr. Lapp believes that the large number of books written about the atomic bomb has produced an unreasonable fear in the minds of the public. He says "like taxes, radioactivity has long been with us and in increasing amounts; it is not to be hated and feared, but accepted and controlled. . . . Radiation is dangerous — let there be no mistake about that, — but the modern world abounds in dangerous substances and situations too numerous to mention. . . . As a killer, the automobile must be placed high on the list, claiming as it does over 30,000 lives a year in the United States alone. This is three times the number of deaths from radiation at Hiroshima. . . . We accept the hazards of the automobile . . . because we are familiar with [it] and have learned to use [it] with some degree of safety. We know how to avoid killing with the automobile even though we do not always follow the correct principles. . . . To achieve the same rational perspective for radiation, both in peace and in war, the public must be thoroughly informed. Ignorance must not breed fear or familiarity contempt."

Much of the book is concerned with discussions of the results of the atomic bombs, comparing them with other forms of destruction, to show their effects are neither catastrophic nor unpredictable. The author's thesis is based on the premise that war appears inevitable and he discusses the annihilation of hundreds of thousands of lives as a matter of course in proving that people can be killed just as efficiently by high explosives and fire bombs as by atomic bombs. This gives the book a starkness which is at times quite terrifying.

At the close of the book he pleads for dispersion of cities and industries. "Like life insurance, dispersion is protection against a disaster we hope will never come."

The cover jacket reflects no credit on the publishers. A naked figure collapsing before a purple mushroom cloud does not convey the spirit of the book at all. The jacket summary misquotes part of the author's first page to change his entire meaning, and would lead one to expect a spectacular expose rather than the level-headed, factual discussion that Dr. Lapp has presented.

SANBORN C. BROWN
Massachusetts Institute of Technology

NEW BOOKS RECEIVED

SCIENTIFIC AUTOBIOGRAPHY AND OTHER PAPERS, *Max Planck*, 1949, *Philosophical Library*. 192 pages. $3.75.

A collection of lectures and writings, in English translation, of one of the greatest contemporary physicists. Some titles of the papers are, "The Meaning and Limits of Exact Science," "Religion and Natural Science."

SOME RECENT RESEARCHES IN SOLAR PHYSICS, *F. Hoyle*, 1949, *Cambridge University Press*. 134 pages. $3.00.

This technical tract in the series of Cambridge monographs on physics presents an account of observational material, followed by a new theory of the origin and structure of the chromosphere and corona.

POPULAR STAR ATLAS, 1949, *Gall and Inglis*, Edinburgh. Unpaged. 5s (before devaluation).

Sixteen maps covering the entire sky to magnitude 5½, and simplified material from Norton's *Star Atlas*, make up this new atlas, intended for use with the naked eye and binoculars.

THE ORIGIN OF THE EARTH, various authors, 1949, *University of Chicago*. 33 pages. 10 cents.

This pamphlet includes the transcription of the recent University of Chicago Round Table radio discussion on the origin of the earth, in which Harrison Brown, Dirk ter Haar, Gerard Kuiper, and Rupert Wildt participated. Two recently published articles on the origin of the solar system are reprinted, one by Dr. ter Haar and the other by Thornton Page. This is No. 598 of the *Round Table* publications, available from the University of Chicago, Chicago 37, Ill.

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GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

PHOTOGRAPHING THE STARS WITH A SMALL CAMERA

PHOTOGRAPHY of the stars was for long a mystery to me, a miracle reserved for the large telescopes. The problem of attaching a camera to the eyepiece or in the focal plane of a small telescope seemed difficult because of the loss of balance of the instrument and the impossibility of checking the accuracy of its movement during an exposure. To these drawbacks was added the difficulty of focusing the image accurately upon the film.

In this article I would like to present a solution to the problem, namely that of obtaining photographs of the stars by using a standard camera, driven by the telescope drive, using the telescope only for guiding.

The method is simple and can be followed by anyone having an equatorially mounted telescope with a clock drive, or, at least, smoothly operating slow-motion gearing. Any camera may serve the purpose although the results depend largely on the quality of the lens.

The solution consisted in replacing the counterweight of my 2½-inch refractor (Fig. 1) by a 35-mm. Leica camera with an Elmar 50-mm. focal length lens, and in lining up the lens axis parallel to the telescope tube. Balancing was done by sliding the camera longitudinally along the extension of the declination axis.

The 35-mm. negatives obtained require strong magnification to be appreciated. Only stars of the 1st and 2nd magnitude can be seen by visual examination of the negative.

For protection against dust and scratches, it is very desirable to handle the negatives with extreme care and to store them between thin, clean glass plates, held together with mounting tape. Enlarged 8 by 10 prints can be made by standard methods, and with the help of a dependable atlas or catalogue the stars can be identified without difficulty. Objects of the 8th magnitude have been identified, and it seems to be possible to attain the 9th magnitude. The resolution, as revealed by the 8 by 10 prints, is about the same as with the naked eye (Fig. 2).

For tracking the stars, my telescope is equipped with a 4-r.p.m. Telechron synchronous motor, which drives the instrument with reasonable accuracy via gears and a worm gear (Fig. 3). Since the barrel of the motor fits rather freely in its armature, corrections of speed are simply accomplished by rotating the barrel in either direction. Thus, the instrument can be kept at the proper rate of motion without any manual adjustment of the tube or of the gearing.

A star in the area to be photographed is observed with the strongest eyepiece of the instrument (about 80 times magnification in my telescope), and is kept in

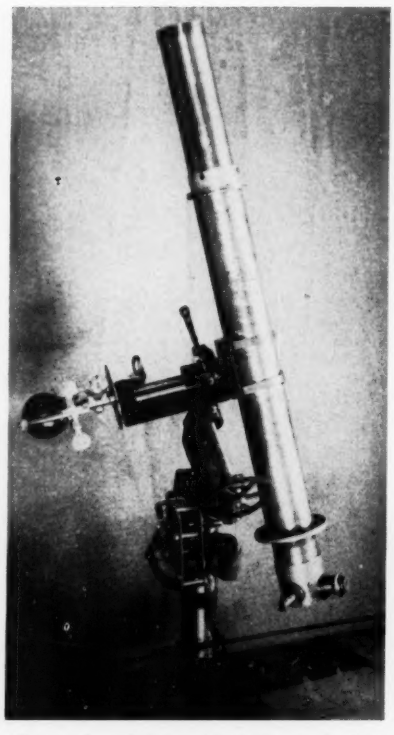

Fig. 1. Luc Secretan's telescope, copied in 1915 from a model by Secretan, Paris. The camera will be attached to the extreme left end of the declination axis.

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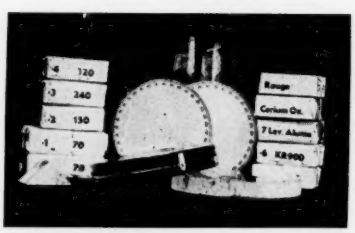

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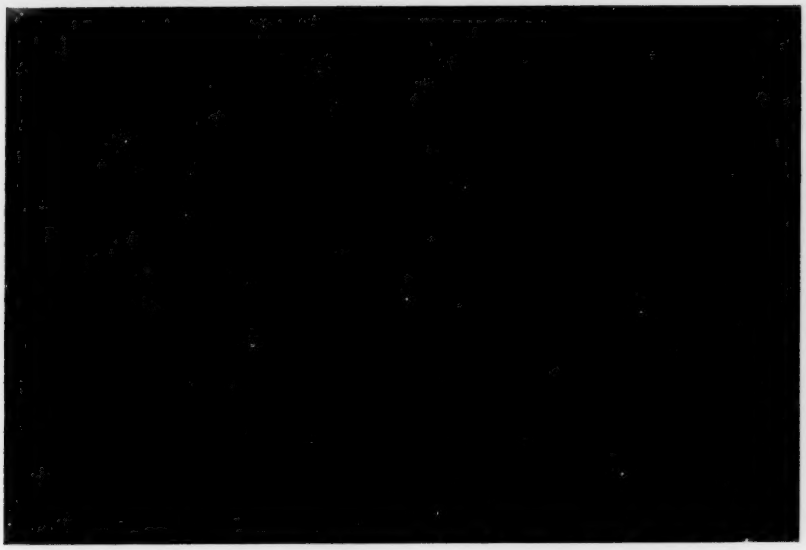

Fig. 2. A field in Bootes, with Gamma Bootis centered, and a weak image of Arcturus on the left edge. Photograph by the author, June 24, 1949, 15-minute exposure on Super XX film; developed in DK60a for seven minutes.

the field by careful observation during the exposure. The use of crosshairs or a similar device may be desirable, but for lack of it another method is suggested. If you keep both eyes open while observing, the star seen through the telescope will appear projected against a background (wall, tree) seen with the "free" eye. It will be sufficient for amateur work to keep the star within narrow limits in the area seen with the "free" eye. The total displacement of the telescope in hour angle during an exposure is small. Notwithstanding this, the apparent shifting of the star against the background must be taken into consideration. It can be estimated in advance before starting the exposure.

Simple as the method may seem, a few requirements must be strictly observed.

1. The telescope with camera attached must rest on an absolutely firm base — for instance, a brick tower topped with a machined base plate.

2. The instrument must have very smooth bearings, but not necessarily ball bearings.

3. The orientation of the polar axis must be so accurate that the instrument will not deviate from its true course by an appreciable amount. Otherwise, corrections in declination become necessary during the

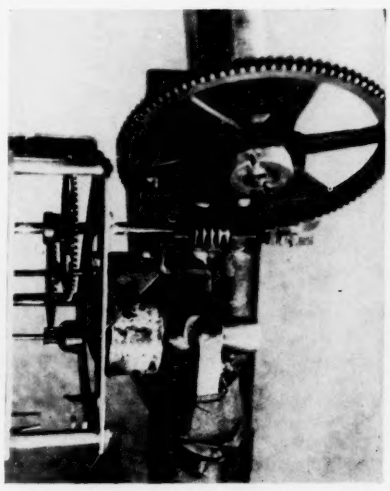

Fig. 3. The driving mechanism, with gears from an old Foxboro recording instrument.

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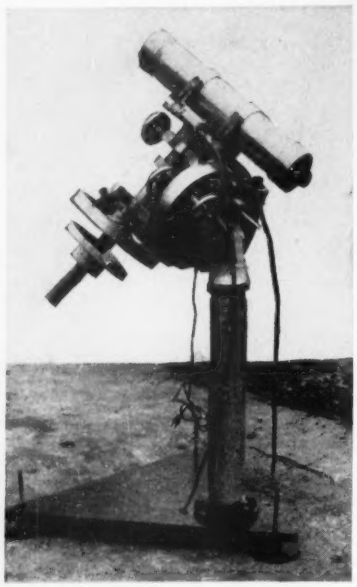

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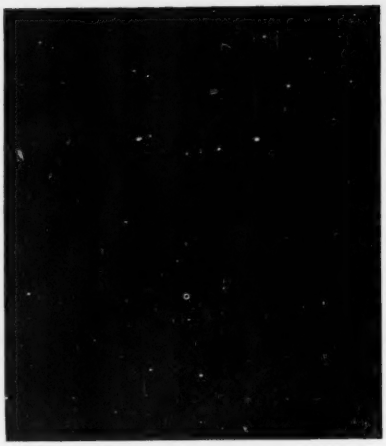

Fig. 4. Corona Borealis and the head of the Serpent, photographed on May 31, 1949, 32 minutes exposure.

exposure in addition to tracking corrections.

4. Absence of wind and of strong street and house lights is of course desirable. As a precaution against sudden flashes of light from the neighborhood, the mounting of a shade around the camera lens is recommended.

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ED. NOTE: Further points on guiding may be found in the article, "Guiding Small Telescopes," by Robert Fleischer, **Sky and Telescope**, August, 1948, page 243.

IN FOCUS

(Continued from page 30)

manipulates the elevator up the left-hand side of the dome slot (looking from the inside out), forward and back until it is in front of the cage. He then drops the door and climbs through the strengthening rods and settles himself to observe. He has guiding controls and telephonic communication with the assistant on the floor below.

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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

MORE ECLIPSE REPORTS

SINCE the November issue went to press, more reports of observations of the eclipse of the moon on October 6th have been received.

Talbot Feild, observing at Durant, Okla., missed totality and the closing phases of the eclipse because of clouds. At Texarkana, Mr. Feild's home town, the eclipse was observed all the way through.

Lacking room at his home in McPherson, Kan., L. E. Hockett secured a favorable location in Lakeside Park, invited McPherson College, telescope owners, and the public to an eclipse party. He set up his own 6-inch reflector and provided a 15-power hand telescope and a pair of 8 x 50 prism binoculars. An important football game was being played at McPherson College, but the stadium faces east, which gave spectators at the game a perfect view of the eclipse. After the game was over many came to the park, where between 500 and 600 persons used the instruments. Mr. Hockett notes that local newspapers and everyone are very co-operative when an event of this nature occurs.

John Walton, at Grand Rapids, Minn., saw the last half of the eclipse, the first part being obscured by rain. Northern lights were visible at times.

Careful watch of the moon during eclipse was kept by members of the Montreal Centre of the Royal Astronomical Society of Canada. Over 40 members gathered at the center's observatory, many taking part in an elaborately planned program that included timing the contacts, plotting of stars visible during totality (to 5th magnitude), recording of color changes, and a record of seeing and weather conditions. Three occultations were timed during totality and a brilliant aurora was recorded. As for meteor impacts on the moon, Robert Venor saw three flashes through the 12-inch reflector that might have been such phenomena. Through smaller instruments two other observers saw no flashes. At his own observatory in north Montreal, F. DeKinder found it hard to distinguish between what might be real flashes and flickers caused by eyestrain, but he recorded four flashes that were "less uncertain" than the others.

At Cedar Rapids, Iowa, Steve Mowrey and John Barwin took several photographs and observed the eclipse through their telescopes. Scattered clouds obscured the moon frequently. At 9:07 CST auroral streamers appeared through a low cloud bank in the north, the individual rays reaching almost to the height of Polaris during the display.

Less than five minutes after totality began, clouds obscured the moon for Charles Clark and other observers at Marshall, Tex. He noticed a 7th-magnitude star southeast of the moon that may have been occulted later during totality.

At Mobile, Ala., however, Joseph Eichberg, Jr., did not see a cloud for the three hours and 15 minutes he observed. He noted that with the naked eye the moon appeared light at some place near the edge of the disk all during totality, and that the eclipse was certainly not as dark as the one of April 12th.

At Lansing, Mich., where a lunar eclipse party was scheduled by the Lansing Amateur Astronomers, complete overcast and rain prevailed during the entire time of eclipse. Nevertheless, about 100 people came to the site where telescopes were to be set up, and the next day's newspaper carried an article on the event and announced the society's plans to conduct a star party next summer.

High, thin clouds produced a halo around the moon during the latter part of the eclipse as seen at Saco, Me., by Francis D. Chapin. He observed northern lights, and took a series of snapshots of the eclipse. He noticed that a deep red filter only darkened totality this time, whereas in April its use seemed to brighten the moon.

The Aristarchus gleam, observed by Frederick K. Vreeland, Mill Valley, Calif., during the April 12th eclipse (see **Sky and Telescope**, October, 1949, page 319), was not repeated this time, according to a letter from Mr. Vreeland himself. The light on Aristarchus during totality seemed merely scattered light from the earth's atmosphere. The crater was brighter than other objects in the umbra, as usual, but without a striking difference in color or the starlike gleam noted in April. Seeing conditions were excellent. The end of totality could not be timed well, as there

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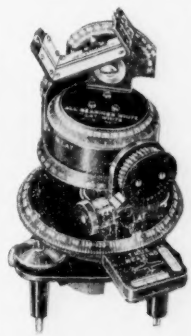

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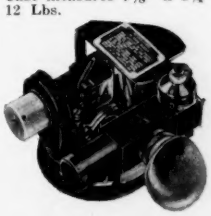

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was no sharp line of penumbral light as in the April eclipse. Mr. Vreeland attributes the bright, yellowish appearance of the outer umbral portions to light scattered in the earth's atmosphere from high cirrus clouds, without much absorption of blue light, whereas in April he believes the light was scattered from low haze.

OBSERVATIONS OF DOUBLE STARS, AURORAE, AND METEORS

"Regarding the article by Leif M. de Kruiff in the October issue, I would like to report that I have gotten a clean separation of both components of Epsilon Lyrae, using an 8-inch f/6 reflector and a power of 32, when seeing was very good." — Alika K. Herring, 2228 Winton St., Middletown, Ohio.

"Upon coming home from a meeting of the AAA of Pittsburgh the evening of October 14th, I witnessed a fine display of the aurora borealis. At first I thought it to be the light of the last-quarter moon, but my mind changed when I saw a bright green streamer rise off the northern horizon and proceed to the zenith. This is the best display I have seen here since the magnificent show of September, 1941." — Gordon Urban, 815 Middle St., North Braddock, Pa.

"On Saturday, October 15th, at Chesterfield, N. H., clouds of a rainy day broke at sunset and there were indications of a bright aurora to the northwest. At 11 p.m. I viewed it again with a clear sky, and it was strongest between the pole star and Vega, with streamers shooting somewhat past the zenith. The northeast was also bright, and the display was a pale green with the usual undulating motion of the rays. In the zenith, the coronal aurora looked like a fan. This was one of the brightest northern lights displays I have seen in a long time." — Leo Mattersdorf, 3400 Wayne Ave., New York.

"On October 26th I saw the trail of what must have been a huge fireball. A neighbor came over at approximately 5:55 p.m. EST, and called my attention to it. He said he and his wife had been watching it for about five minutes or more. When I first viewed the trail, it was fiery brilliant, but slowly faded. By 6:00 p.m. it had disappeared. The trail was low in the southern sky from Inverness, about 10 degrees above the horizon, with a total length of about three degrees. The sun had set, but it was still bright daylight. The trail extended east and west, almost horizontally. I would be interested in hearing from other observers of this phenomenon." — Roland E. Hart, Inverness, Fla.

"Here in North Carolina interest in astronomy and in the observing of meteors has been greatly stepped up, in part of course due to the opening of the Morehead Planetarium. This summer we observed and plotted both the Delta Aquarid and Perseid meteor showers, and the plots for the former far exceeded those of the more widely publicized Perseids. For our new observers, there were a number of thrills, especially when a train was left or a 1st-magnitude meteor appeared. All our reports have been forwarded to Dr. Charles P. Olivier, director of the American Meteor Society." — F. B. Eason, 504 W. Vance St., Wilson, N. C.

GEMINID METEOR SHOWER

The second best shower to the Perseids may be watched this month under favorable conditions, as the moon is waning rapidly during maximum. Originating from an area near Castor, the Geminids are at maximum December 11th to 13th, the hourly rate being 60 meteors. Normal limits for the shower are December 9th and 14th. This generally rich shower is best observed before midnight, with white meteors of medium velocity predominant.

E.O.

MOON PHASES AND DISTANCE

Full moon	December	5, 15:13
Last quarter	December	13, 1:48
New moon	December	19, 18:55
First quarter	December	27, 6:31
Full moon	January	4, 7:48

	December		Distance	Diameter	
Apogee	1d	6h	251,900 miles	29′	29″
Perigee	17d	7h	226,500 miles	32′	47″
Apogee	29d	0h	251,400 miles	29′	32″

MINIMA OF ALGOL

December 1, 6:59; 4, 3:48; 7, 0:37; 9, 21:26; 12, 18:15; 15, 15:04; 18, 11:54; 21, 8:43; 24, 5:32; 27, 2:21; 29, 23:10.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See **Sky and Telescope**, Vol. VII, page 260, August, 1948, for further explanation.

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THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

The end of December finds the five bright planets visible some time between sunset and midnight. Eastward from the sun will be Mercury, Jupiter, Venus, Saturn, and Mars.

The sun attains its southernmost declination on December 22nd at 4:24 UT, the December solstice. Winter commences in the Northern Hemisphere and summer in the Southern.

Mercury, east of the sun in the evening sky, may be easily located the last two weeks of the month. Setting from one to 1½ hours after the sun, the elusive planet will be about −0.5 magnitude. Greatest elongation is attained on January 1st.

Venus cannot go unnoticed this month as the brilliant object in the southwest after sundown. Maximum brightness, −4.4, occurs one day after Christmas. Greatest brilliancy takes place midway between elongation and conjunction with the sun. The planet sets three hours after the sun for mid-northern observers. In a telescope, Venus will appear 26 per cent illuminated, and 41″ in diameter on the 26th. The three-day-old moon, passing 3° 41′ south of Venus at 23:05 UT, will aid one to observe the planet in the daytime.

Mars arrives at western quadrature on the 19th, rising at midnight. The planet is now 1st magnitude and moving eastward in Leo and Virgo. A close conjunction with the moon takes place on December 13th at 8:43, Mars being 33′ north for a geocentric observer.

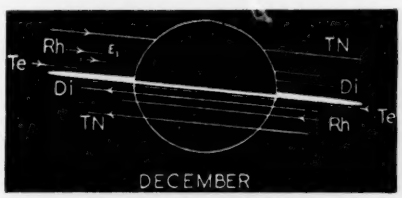
Jupiter sets three hours or less after the sun, and is of little interest now. Venus passes 2° south on December 7th at 3^h UT, outshining Jupiter by 2½ magnitudes.

Saturn, in eastern Leo, rises before midnight local time. Western quadrature with the sun occurs on the 11th.

Saturn will be of exceeding interest in a telescope from now through 1950. The rings are tilted only 1½°, the major axis is over 40″ across, and the minor about 1″. The planetary disk is 16″ in diameter.

Uranus comes to opposition on December 25th, 1,669 million miles from the earth. The planet is in retrograde motion, a little over a degree north of Mu and Eta Geminorum. On the 9th, Uranus passes 2′ north of a 7th-magnitude star, as shown in the chart on page 134 of **Sky and Telescope,** March, 1949. The planet is of magnitude +5.8.

Neptune will be above the horizon in the morning hours. It is 8th magnitude and located approximately 1′ west of Theta Virginis at the end of the month. For its path, see the chart on page 134 of the March issue. E. O.



The apparent paths this month of Saturn's satellites Dione, Rhea, Tethys, and Titan, relative to the planet and its rings. South is at the top. Tethys' path will appear very close to the rings. From the 1949 "Handbook" of the British Astronomical Association.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

THE INDEX TO VOLUME VIII

of **Sky and Telescope** is now on sale. This and the indexes to previous volumes cost 35 cents each, in coin or stamps, or included in the payment of the renewal of your subscription.

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SKY PUBLISHING CORPORATION
Harvard College Observatory
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DEEP-SKY WONDERS

THIS COLUMN receives a small but constant stream of letters from observers who have been unable to locate the open spiral galaxy M33 in Triangulum. Many of them decide that its chart position is in error, but such is not the case. It is at 1^h 34^m, +30° 24′.

The visibility of a galaxy or nebula to the eye is a function of many factors, among which are aperture and magnifying power, contrast between the nebula and the sky background, the ratio of sky area to nebula area in the field of view, Ricco's law, and Piper's law. The laws may be inspected in detail in the **Handbuch der Astrophysik** and in the **Dictionary of Applied Physics.** Here we cannot discuss their applications, but the following points are worth consideration.

1. Use a power of 4 per inch of objective diameter for best results on large nebulae.

2. Use as wide-field an ocular as possible.

3. On small nebulae, higher powers will under some conditions give a better view.

4. Although the estimated magnitude of a nebula decreases with larger telescopes, the larger instrument will show fainter objects.

5. Many faint nebulae can be seen only with very small or very large instruments, being invisible in telescopes from four to 10 inches.

6. Remember that published magnitudes refer to integrated photographic values, and eye visibility may be much different. This is especially true for objects of large area such as M33, where the operation of Piper's law makes the eye visibility much fainter than the overall photographic magnitude.

As a test, the writer examined M33 with a variety of instruments. In a 2-inch finder, it was easily seen. In a 4-inch refractor, 60x, it was very difficult, and a friend of mine could not see the galaxy at all. In a 6-inch rich-field reflector, 20x, it was fairly easy to see, but my friend had difficulty. In an 11-inch refractor, with 60x, M33 was fairly easy, and in a 16-inch refractor it was quite easy with 100x.

Amateurs with medium-sized instruments will have trouble with M33 unless they use powers of around 4 per inch of aperture and an eyepiece with a one-degree field.

WALTER SCOTT HOUSTON

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FOR SALE: Copies of a new publication, "Telescopic Observations of Mars." Recorded observations made with small instruments during the apparitions of 1941—1943—1945-6 and 1948 with descriptive text concerning the observable markings. This is the third in a series of similar publications. 200 drawings and maps, 60 pages, cloth bound. Price $2.50. H. B. Webb, 145 President St., Lynbrook, N. Y.

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FOR SALE: 12" achromatic telescope objective by Lundin. Standard Alvan Clark design. For particulars and price write R. B. Bourne, 27 Sulgrave Road, West Hartford 7, Conn.

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WANTED: I will buy good small refractor or reflector if priced right, and perfect condition. Defries, 290 Malvern, Memphis, Tenn.

BARLOW LENS: Send stamped return envelope for free six-page educational information as to how a Barlow can greatly improve your telescope images and magnifications. F. Goodwin, 345 W. Belden Ave., Chicago 14, Ill.

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JUPITER'S SATELLITES

IN RESPONSE to the request for opinions last month, all votes have been in favor of returning to the reproduction of Jupiter satellite charts from the **American Ephemeris and Nautical Almanac.** The current chart is printed here this month. During the early part of 1950, however, Jupiter will not be favorably placed for observation, so further satellite charts will not appear until later in the year.

Some comments received concerning the charts are:

"Please return to the diagram. It is much more useful to show the general public when viewing Jupiter at the Cranbrook Institute of Science Observatory." — William Schultz, Jr., Bloomfield Hills, Mich.

"As a subscriber to your magazine and an owner of a 6-inch reflector I have really missed the charts of Jupiter and its satellites." — John M. Feely, Hollywood, Calif.

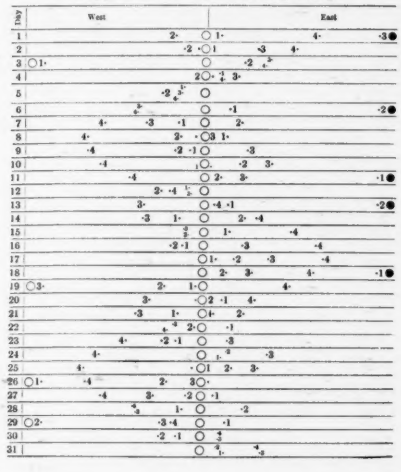
"I am all for such a change, for it will enable one to tell at a glance the approximate positions of the moons, which is impossible under the present system. Those enthusiasts who wish to time eclipses, and so forth, are usually in possession of more detailed publications. For the majority of amateurs, who only take casual glances at Jupiter, the diagrams should prove far more satisfactory." — Joseph A. Anderer, Chicago, Ill.

"I can get the eclipse, transit, and occultation times from the **Observer's Handbook** of the Royal Astronomical Society of Canada, but never know what the relative positions in respect to the planet will be. How about going back to the old way next year." — Edwin V. Greenwood, Toronto, Ont.

"The **Ephemeris** charts are, I am sure, much more useful to active observers of the planet. It is utterly impossible to tell from tabulated numbers whether the distance between some two adjacent satellites is half of their own diameter or 15 times the diameter of Jupiter, for example. Moreover, the satellite numbers are used on the charts in such a way as to show the direction of motion of the satellite at the time given. This information can be extremely useful if an observation is made at a time some hours before or after that for which the data are supplied. In fact, it may be quite necessary to know something of the distance between two satellites and of their motion since the time at which they were reported in order to identify them positively. Presumably the chart is given to permit such identification. For these reasons I should like to urge, as director of the Association of Lunar and Planetary Observers, that the **Ephemeris** diagram be employed in **Sky and Telescope** in 1950." — Walter H. Haas, Albuquerque, N. M.

Jupiter's four bright moons have the positions shown below for the Universal time given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. This chart is reproduced from the American Ephemeris and Nautical Almanac.

Configurations at 23h 0m for an Inverting Telescope



OCCULTATION PREDICTIONS

December 12-13 **Beta Virginis** 3.8, 11:48.0 +2-03.1, 23, Im: **B** 11:09.9 ... ... 201. Em: **B** 11:33.6 ... ... 238.

December 30-31 **Zeta Arietis** 5.0, 3:12.0 +20-51.4, 11, Im: **A** 4:30.2 −1.4 −0.7 77; **B** 4:27.0 −1.4 −0.4 67; **C** 4:26.8 −1.7 −1.2 90; **D** 4:19.3 −1.6 −0.4 73; **E** 3:58.2 −2.1 −0.1 79; **F** 3:45.6 −3.5 −1.5 106; **G** 3:40.9 −0.5 +3.2 16; **H** 2:56.9 −1.3 +2.2 48; **I** 3:33.8 +0.2 +4.1 3. Em: **A** 5:45.9 −0.9 −0.7 249; **C** 5:42.2 −1.2 +0.2 234; **E** 5:23.1 −1.6 +0.5 235; **F** 4:54.8 −1.7 +3.5 201; **H** 4:23.4 −2.2 +1.2 246.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, all data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, **UT**, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

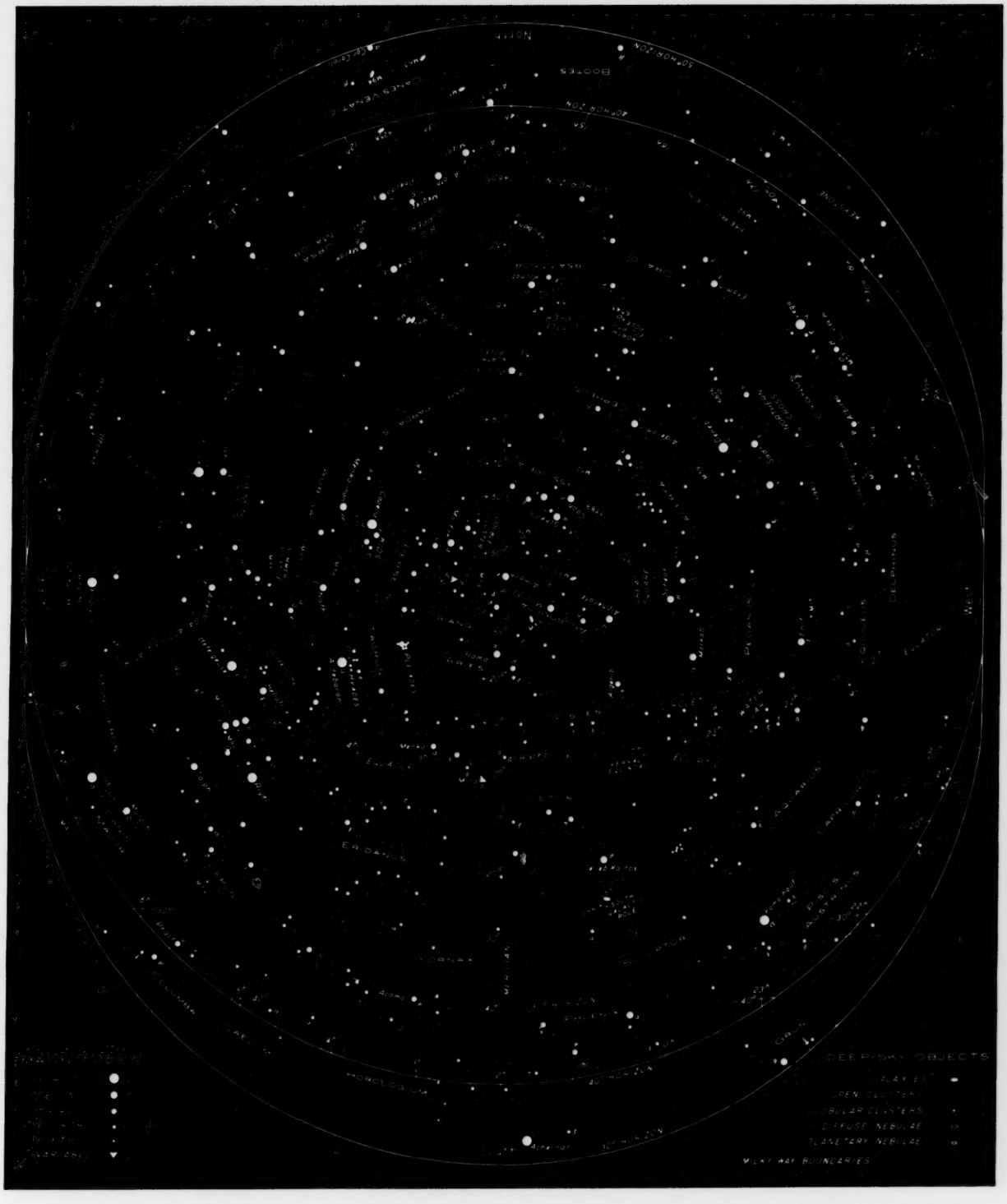
Longitudes and latitudes of standard stations are:

A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +30°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
		I	+123°.1, +49°.5

VARIABLE STAR MAXIMA

December 3, T Aquarii, 7.9, 204405; 11, S Hydrae, 7.9, 084803; 12, V Monocerotis, 7.1, 061702; 15, X Monocerotis, 7.6, 065208; 17, R Corvi, 7.6, 121418; 19, S Sculptoris, 6.8, 001032; 29, R Leonis, 5.9, 094211.

These predictions of variable star maxima are by Leon Campbell, honorary recorder of the AAVSO. Only stars are included whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).



The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of December, respectively.

STARS FOR DECEMBER

LOOKING to the stars at Christmas is of little avail when one seeks an answer to the riddle of the Star of Bethlehem, if that legendary event actually does have a physical explanation. This year's December finds Venus at her best in the western evening sky, while Jupiter adds his splendor to the scene. Could either of these planets have been the "star" alluded to in the ancient story of the travels of the Wise Men?

When one considers that the early shepherds spent considerable time outdoors at night, and when we note that constellation study and planetary motions constituted most of astronomy for the ancients, it is hard to believe that they could have been confused by any appearance of Venus and Jupiter and the lesser planetary lights. The "triple conjunction" of Jupiter, Saturn, and Mars that occurred near the time of Christ's birth was too near the sun to be seen above the horizon after sunset (although with the sun projector turned off the conjunction makes a stirring sight in some planetarium Christmas shows).

A comet or a nova would seem better candidates for Star of Bethlehem fame; at least the ancients would not have been familiar with them beforehand.